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PROPOSED LEGISLATION FOR ARTIFICIAL GROUNDWATER RECHARGE

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by

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PROPOSED LEGISLATION OF ARTIFICIAL GROUNDWATER RECHARGE

I. INTRODUCTION

"We travel together, passengers on a little space ship, our world, dependent on its vulnerable resources of air and soil, all committed to its safety, to its security and peace, preserved from annihilation only by the care, the work (and I will add, the love) that we give our fragile craft."

Adlai Stevenson, in his last address before the United Nations

Much research has been conducted in artificial groundwater recharge the last twenty years, and particularly within the last decade, since the public's realization that our world is having pollution problems. The present scientific emphasis is being placed on the total systems approach of recycling and reclaiming as much of our waste production as is possible. It is the hope of its author that this article which embraces this principle will prove to be useful in the nation's drive to enhance the quality of its water resources.

It is as much the purpose of model legislation to enlighten the public and their representatives as it is to come up with an ultimate solution. Suggested legislation should be general in nature with its details being worked out by regulation. This insures much needed initial flexibility. With this in mind the article is divided into four parts:

1. Technological Considerations
2. Legal Considerations
3. Present Legislation
4. Proposed Legislation

Part One evaluates the technological complexities involved, and lays the foundation on which the proposed legislation is predicated. Part Two elaborates the legal problems involved and stresses the various possible liabilities incurred by anyone who attempts to use the process of artificial groundwater recharge. Part Three reviews the current legislation in the area, and Part Four is the statement of the proposed legislation.

II. PART ONE: TECHNOLOGICAL CONSIDERATIONS

A. Definition of Artificial Groundwater Recharge

Artificial groundwater recharge, herein designated as A.G.R., is most easily understood by contrasting it with natural groundwater recharge. Natural groundwater recharge consists of that portion of the hydrologic cycle which replenishes the earth's groundwater. The hydrologic cycle is the natural reoccurring process through which water passes from its form as atmospheric water vapor into its liquid form as precipitation which then moves along the earth's surface or into the ground and finally returns again to the atmosphere by either evaporation or transpiration.[1] So it is by means of infiltering rainfall or leakage from the bottoms of lakes, rivers and streams that the natural process of groundwater recharge is carried out. In contrast, when man intervenes within the natural process and introduces various effluents into the groundwater supply, he is artificially recharging the groundwater. Basically then, A.G.R. encompasses any man-made process or human activity which introduces any kind of liquid into the underground.

This simple explanation of A.G.R., however, is quite deceptive for a number of factors complicate its general description. The first major factor which complicates the description of A.G.R. is purely a semantical one. For example, there are numerous terms of art, each of which is presently the subject of intense scientific investigation, which are either used synomously with or so closely related to A.G.R. that their true significance is often lost. Among these terms, many of which will be clarified later in the paper, are wastewater reclamation, subsurface disposal, deep-well injection, spray irrigation, and underground wastewater disposal to name just a few. It is readily apparent that anyone could lose sight of the A.G.R. forest by simply seeing only these semantical trees.

A second cause for much confusion is the failure to recognize the vast number of different effluents used in the recharge process. Recharge effluents currently being used include cooling waters, surface and storm waters, domestic and industrial wastewaters (treated and untreated), and irrigation waters. Citing as but one example, A.G.R. injection systems, it has been said that virtually all types and significant quantities of industrial wastewaters are being pumped underground.[2] These wastewaters include alkalies, acids, chromates, nitrates, phosphates, sulfites, a variety of organic materials, such as alcohols, ketones, phenols, cyanides, and chlorinated hydrocarbons, as well as radioactive wastes and other toxic and refractory contaminants.

Additional A.G.R. complications arise from the fact that varying types of processes are involved. For example, certain

A.G.R. systems utilize the biologically active surface of the soil mantle as a tertiary wastewater treatment mechanism.[3] The significance of this means of treatment is elaborated upon in great detail in subsection II(C) of the paper. In contrast, other A.G.R. systems do not use the soil mantle as a treatment process, but rather as only a disposal or storage mechanism.[4] This practice, too, is discussed in much detail later in subsection II(D) of the paper.

The final consideration in describing A.G.R. practices is a brief description of the various means by which they can be implemented. Unfortunately, here too, the multiplicity of methods used adds to the complexity of A.G.R. Those A.G.R. systems which utilize the soil mantle as a means of advanced wastewater treatment use almost exclusively some means of surface spreading. Surface spreading can in turn be accomplished by a number of methods including spray irrigation, impoundment, controlled flooding, or diffusion wells. Another A.G.R. system, which was mentioned above, injects the recharging effluent into the ground through either deep or shallow wells. The final means of affecting A.G.R. is by the use of induction wells which create a negative pressure in the recharge basin due to the drawdown of the groundwater table around the discharging (induction) wells.

Before passing to the next subject of the paper, it may be appropriate to mention that the definition of A.G.R. developed herein has been quite general. A number of scientists and engineers may take objection to the inclusion of deep-well injection or disposal operations within it, but this author

feels that subterranean injection practices which potentially could affect the quality of the usable groundwater resources must be included within the auspices of the suggested legislation, or otherwise it too would become another example of piecemeal legislation.

B. Significance of Artificial Groundwater Recharge

A.G.R. systems offer numerous potentially significant environmental utilizations. Although closely interrelated, the most significant of these usages are listed as follows:

1. A.G.R. treatment systems provide a potential wastewater treatment mechanism for all domestic and certain industrial wastes.
2. A.G.R. treatment systems provide a means to increase the quantity and quality of the nation's water supply resources.
3. A.G.R. treatment systems provide a means to effectively abate and potentially eliminate the nation's water pollution problems, which correspondingly could improve the overall state of health of all the inhabitants of America, as well as the world.
4. A.G.R. systems provide a means to protect the nation's coastal areas from additional saltwater intrusion.
5. A.G.R. systems provide a readily available storage area for potable waters or other valuable liquid resources.
6. A.G.R. non-treatment systems may possibly provide convenient and economical disposal by permanent subterranean storage of noxious and refractory chemical pollutants.

The interrelationship of these potential A.G.R. utilizations is readily apparent because each presents a possible solution to one or more of our nation's pressing environmental problems. A separate discussion of each A.G.R. usage listed, although itself valuable, is not a necessary requisite to the end sought to be

achieved by this paper. It would be more profitable to discuss the A.G.R. "treatment -- non-treatment" system dichotomy which was alluded to earlier.

In looking at A.G.R. systems which provide an advanced wastewater treatment function, it can be seen that the usages one through five listed above may be directly affected. Similarly, those A.G.R. systems which do not provide any significant wastewater treatment, i.e., storage or disposal only, embrace the advantages of the usages three, four, and six. Accordingly, a discussion of such a dichotomy will not divorce itself from these potentially significant utilizations, for it is not the intent of the author to avoid a separate discussion of each, but rather to shift the reader's consideration of the principles of A.G.R. systems to one through which proposed legislation can be more effectively implemented.

Before discussing the technological complexities involved with each section of the treatment -- non-treatment A.G.R. dichotomy, it is appropriate to mention some other significant advantages associated with the use of such systems. The additional advantages are associated with the development, maintenance, and protection of subterranean A.G.R. water supplies.[5] Groundwater supplies can be developed in stages as needed corresponding to an area's population increase and industrial growth. Also, A.G.R. water supplies have no evaporation losses and are protected from pollution and radioactive fallout.

C. Artificial Groundwater Recharge Treatment Systems

Professors P. H. McGauhey and R. B. Krone[6] concluded in 1967 that there is a considerable body of literature now existing relative to the changes in quality which occur in water passing through the biologically active surface zone, as well as the inactive saturated strata of the earth's mantle. Having reviewed and analyzed nearly four hundred references associated with the use of the soil mantle as a waste treatment system, McGauhey and Krone concluded further that there is enough information in the literature to permit the fully informed and imaginative engineer to exploit the earth's soil mantle as a waste treatment mechanism.[7] Although their research went into great detail concerning the various quality changes obtainable from such a system, this author feels that only certain general explanations of the type of treatment to be expected are essential for the purposes of this paper.

Perhaps their most significant conclusion dealt with bacteria and viruses.[8] Research findings on the travel of bacteria and viral pollutants with percolating waters and with groundwaters in saturated aquifers revealed that the soil mantle as an A.G.R. treatment system is efficient in removing both such biological antagonisms. It was concluded that bacteria behave like other particulate matter in soil, and in addition to their subjectivity to "die-away" under the unfavorable environment often found on the earth's surface, they are removed from the waters by straining, sedimentation, entrapment and absorption. Similarly, viruses are removed by soil systems, even more effectively than bacteria, principally by adsorption with clay and sand particles.

In contrast to the high efficiency in bacterial and viral removals, it was concluded that the ability of soil systems to remove chemicals from percolating water is much more limited. In general terms, McGauhey and Krone concluded that any chemical which is not removed or altered in the biologically active unsaturated zone which overlies the watertable must be presumed to be unaffected by the soil system and accordingly to be beyond its ability to remove.[9] Biodegradable organic materials which are normally associated with domestic wastewaters are attacked in the clogging zone and reduced to intermediate compounds and ultimately to stable compounds which characterize groundwater, e.g., nitrates, phosphates, carbonates, sulfates, etc. Other ions which are normally associated with industrial wastewaters must be more closely considered. Although phosphates and synthetic detergents are effectively removed in the soil mantle such refractory contaminants as chromates, gasoline, phenols, citric acid, and other such chemicals have been observed to travel many miles and hence, in general, soil systems must be considered ineffective in treating many industrial wastewaters.

By-passing momentarily the technical conclusions drawn by McGauhey and Krone let us look to other sources which indicate the feasibility of A.G.R. wastewater treatment systems. In the 1971 revised edition of THE RECOMMENDED STANDARDS FOR SEWAGE WORKS,[10] the Great Lakes-Upper Mississippi River Board of State Sanitary Engineers (GLUMRB) proposed standards for construction and use of ground disposal systems for wastewaters. These standards, if met, indicate to the satisfaction of GLUMRB that

the soil mantle can be used as a treatment facility prior to the actual recharge of the groundwater supply. The GLUMRB members well recognize that since the protection of groundwater and surface resources is a major concern in the development of such guidelines, practices must be established to prevent wastes of any nature from being introduced into the fresh groundwaters which will so change their characteristics as to make them unsuitable for water supplies or other present or future usages.[11] The recommended standards describe the major factors for the design of ground disposal operations but since they are not of themselves the primary concern of this paper, they are not mentioned further herein.

Having seen that scientists and engineers have concluded that A.G.R. reclamation systems are feasible, it seems reasonable to now turn our attention to those systems which have actually been in operation to evaluate their effectiveness. One evidence of the effectiveness of the soil mantle as a wastewater treatment mechanism must be the fact that reclamation has been accomplished for years by the use of cesspools, seepage pits, and septic tanks in most rural areas of the world.[12] Since it is estimated that approximately twenty percent[13] of the United States population presently disposes its domestic borne wastes underground by such means without significant complaint, its efficacy has clearly been demonstrated.

One of the first major applications of the A.G.R. systems treatment principles was in the Whittier Narrows Water Reclamation Plant, Orange County California. It artificially recharges

12,000,000 gallons a day of domestic and industrial wastewaters to meet the current U. S. Public Health Department's Drinking Water Standards.[14] Since it began operation in the fall of 1962, it has demonstrated to the general public the feasibility of producing good quality water from wastewater.[15]

To date there are relatively few applications of spray irrigation disposal (recall this is but one means of artificially recharging the groundwaters). There are, however, in California, some thirty installations serving generally small communities.[16] In contrast to these relatively small operations is the A.G.R. spray irrigation system of Muskegon, Michigan, a city with a population of approximately half a million people. Having a recharge basin with an area of nearly 6,000 acres, its operation has been and is the subject of continuing intense scientific research.

The Muskegon Project, described as a resource management approach to the treatment of wastewaters,[17] was developed by a team of scientists and practicing engineers to provide a total solution to the problem of water quality degradation. It was selected along with Ottawa County, Michigan as a pilot test area for a feasibility study of a large scale A.G.R. spray irrigation treatment system. Dr. John R. Sheaffer, Research Associate, Center of Urban Studies, University of Chicago, in a prepared statement before the Subcommittee on Conservation and Natural Resources,[18] described the operation as follows: The Muskegon wastewaters are brought to a geologically suitable recharge site through a pipeline. The wastewaters then pass through a series

of treatment lagoons which were constructed at the site to provide aeration to satisfy the biological oxygen demand, settling to remove settleable solids, aerobic bacteria to consume soluable organic wastes, and photosynthetic cells to convert nitrates and phosphates into algal cell material which can be retained by the soil. The lagoon treatment facility alone produces an effluent superior in quality characteristics to that of the secondary sewage treatment plant, for research has shown that a lagoon providing thirty days retention time reduces the viral content of its effluent by seventy percent, whereas no viral removal is obtained by secondary treatment plants.[19] Following its partial treatment in the lagoon system, the upgraded wastewater effluent is applied uniformly to the geologically suitable site by large rotating irrigation rigs in a manner which maintains the necessary aerobic conditions.

In appraising the ability of the A.G.R. treatment system just described Dr. Sheaffer stated:

> The resource management approach can effectively reduce the whole range of pollutants, because it encompasses a number of treatment mechanisms. In the treatment lagoons, the solids settle out, heavy metals settle out, the aeration reduces the BOD; the nitrates and phosphates are fixed in algal cell material. The wastes, when applied on the land, are treated by the biological zone or living filter. Dissolved nutrients are removed along with heavy metals and viruses. The heavy metals that pass through the treatment lagoons are held by the organic matter and the clay, or are taken up by the plants. The viruses are held by the sand or clay particles. The nutrients are taken up by the plants. And we have more or less good quality water moving down to the water table.[20]

Having concluded that A.G.R. treatment systems are technologically feasible, it becomes appropriate to next consider their

economic feasibility. It was the conclusion in studies made on an A.G.R. treatment system similar to the Muskegon Project located near Tel Aviv, Israel, that conventional wastewater treatment is not necessary in order to produce an effluent suitable for groundwater recharge by surface spreading.[21] Similarly, since the Muskegon Project involves no prior-conventional treatment to its spray irrigation operation, Dr. Sheaffer demonstrated a benefit-to-cost ratio of 1.69 in his economic analysis of the wastewater management project.[22] It should be emphasized also that Dr. Sheaffer's economic analysis included no beneficial gain by the possibly improved health of the area's inhabitants because of disease reductions due to the bacteria and viral removals associated with this system. Similarly, no beneficial gain was claimed for lower treatment costs for the production of the area's necessary drinking water. It is also worth noting, that A.G.R. treatment basins may often utilize marginal or other relatively unproductive land areas for the applications of the wastewaters rich in the fertilizer elements of nitrogen, phosphorous, and potassium. Accordingly, additional economic gain can be obtained by the conversion of these marginal lands into agriculturally productive areas, e.g., tree farms, etc.[23]

Additional support for these systems economic feasibility was given by H. Bouwer.[24] He concluded that soil and hydrogeological conditions permitting, the cost of renovating sewage effluent by groundwater recharge through surface spreading is a fraction of that of comparable tertiary "in-plant" treatment. Accordingly, A.G.R. treatment systems are less costly than the

present conventional systems and surprisingly provide a much higher degree of wastewater treatment.

D. Artificial Groundwater Recharge Non-Treatment Systems[25]

The number of deep-wells for wastewater disposal is increasing throughout the country. These industrial waste injection systems, i.e., A.G.R. non-treatment systems, have become increasingly attractive as a result of the more stringent water pollution control requirements being imposed on surface waters by government.[26] Statistics confirm this trend. It is estimated that there were six industrial waste injection systems in the United States in 1953, 35 in 1963, and 150 in 1969.[27] Note however, these figures do not include oil-brine disposal installations which were estimated at over 40,000 in 1969.[28]

Chemical, petrochemical and pharmaceutical industries have installed more than half of these deep-well systems, the wastes from which often include toxic and refractory contaminants.[29] As stated earlier, virtually all types and significant quantities of industrial waste effluents are presently being pumped underground.[30]

Mr. Cleary[31] concluded that it is obviously too premature for proponents of this practice to postulate that injection wells offer a complete and final solution to the disposal problem. In fact, he warns it may be improper to affiliate the term "disposal" with this technique. Actually, injected liquids are only being committed to storage, often with uncertainty as to the ultimate confinement limits involved. As noted previously, there is little evidence to suggest that conditions underground are conducive to

the degradation or dimunition of most pollutants to a concentration which can be regarded as innocuous.[32]

The monograph[33] describes Dr. Harold A. Thomas, Jr., Professor of Sanitary Engineering at Harvard University, as one of the earliest advocates of caution concerning the use of A.G.R. injection systems. In 1962, he expressed the view that while injection-well installations appear capable of providing economical disposal of wastewater, their potential hazards and uncertainties must first be weighed in the national interest. Realizing that many aquifers and other geological formations underlie two or more states and are connected directly or indirectly with interstate waters, Dr. Thomas proposed the establishment of a national registry for injection systems.[34] The registry's primary function would be to serve as a means of collecting and disseminating data useful in identifying and utilizing the suitable subterranean strata for wastewater disposal. This much needed information would provide a means of establishing the environmental hazards involved, safe operating practices, and ultimately effective legislative regulation.

It is noteworthy that shortly after an advance draft of the monograph was submitted to the Federal Water Pollution Control Administration for review, the Secretary of the Interior, Walter J. Hickel, issued a press release regarding underground waste injection, saying among other things: "We must review existing regulations and start collecting the kind of environmental data needed to assess the level of risk, and consider ways of organizing federal, state and industrial efforts to solve this growing problem."[35]

This study attests that much has been done to fulfill his charge to technological science, but of course, it is only a beginning. Presently, it can only be concluded that A.G.R. injection systems offer a convenient and economical but possibly environmentally hazardous means of waste disposal. The presently available data makes it impossible to conclude otherwise. Research must continue.

E. Technological Summary

This subsection and the one which follows attempts to tie all the foregoing together in such a manner as to provide the reader with as much overview of the technological considerations of A.G.R. systems as is possible. The subsection consists of a list of simple generalizations about A.G.R. systems. Although each one is most susceptable to exception, as is any generality, the list provides legislative draftsmen with a brief summary of the technological constraints which must be maintained and the potential advantageous utilizations which should be endorsed.

I. Basically, artificial groundwater recharge is any man-made process or human activity which introduces any liquid into the underground.

II. Although the general underlying principles are easy to comprehend, A.G.R. systems are greatly complicated by:

   A. The divergent sciences which comprise its numerous distinct components.

   B. The multitude of different effluents used in its practice.

   C. The numerous means by which the practice can be implemented.

III. A.G.R. systems can be categorized into two distinct classifications based on whether or not the surface of the earth's soil mantle is used as a treatment mechanism. They are:

A. A.G.R. treatment systems, which provide advanced wastewater treatment for domestic and certain industrial effluents, and

B. A.G.R. non-treatment systems, which provide little significant treatment, i.e., only subterranean storage, of toxic and refractory industrial wastewaters.

IV. A.G.R. treatment systems have been demonstrated to be technologically and economically feasible in virtually all areas of the United States.[36]

A. A.G.R. treatment systems provide advanced treatment for biological and suspended matter, for nitrogen and phosphorus compounds, for detergents, for toxic heavy metals, and for bacteria and viruses which under the present means of treatment are receiving little or no removal.

B. A caveat about A.G.R. treatment systems is in order regarding their limited chemical treatment capabilities: Any chemical which is not removed or altered in the biologically active unsaturated zone overlying the water table must be assumed to be unaffected by the soil system, and accordingly, beyond its ability of removal.

V. A.G.R. non-treatment systems offer a convenient and economical means of disposal of refractory chemical contaminants, but one which may be environmentally hazardous to the potable water-bearing aquifers.

A. More data must be collected to assess the environmental hazards involved with A.G.R. non-treatment operations.

B. Until such time as A.G.R. non-treatment systems are declared safe, their proliferation should not be permitted.

VI. If found to be safe, widespread adoption and utilization of both types of A.G.R. systems offer a myriad of potential environmental and socialogical advances by providing:

A. A means of wastewater treatment for domestic and certain industrial wastes which is economically and technologically superior to the in-plant processes currently being used.

B. A means to improve and increase the nation's water supply, while

1. Providing a readily available large reservoir for storing potable waters without evaporation losses, and

2. Providing protection from pollution and radioactive fallout, and

3. Which can be developed in stages corresponding to an area's population increase and industrial growth.

Where does all this lead us? The final subsection of the technological portion of the paper which follows addresses itself to this question. Hopefully, it will have a suitable answer which will give sufficient insight to develop the necessary legislation needed to implement the solution.

F. Technological Conclusion

It has been estimated that approximately twenty percent of the freshwater withdrawn for use in the United States is groundwater.[37] Although that figure seems quite small, in some parts of the United States groundwater is much more highly consumed. In Florida, for example, it has been estimated that at least 86 percent of the population depends on groundwater for their domestic uses.[38] Accordingly, it can no longer be conjectured that groundwater is one of the nation's most important natural resources,

for as our population expands and our country grows industrially it is readily apparent that proper conservation and utilization of this precious resource is vital. As concluded earlier by GLUMRB,[39] practices must be established which will help prevent waste of any nature from being introduced into the fresh groundwaters which will so change their characteristics as to make them unsuitable for present or future usages. It seems apparent, then, that since groundwater is the classical alternative to surface water as a natural resource and is a principle source of water supply for domestic, municipal, industrial, and agricultural uses, that we cannot well afford to have our ground waters polluted in the same way that we have allowed many of our surface waters to become.

A simple hydrological observation indicates that the soil system has an ability to upgrade the physical, chemical, and biological qualities of water. It is a fact that rain has for ages fallen through an atmosphere containing dust, smoke, bacteria and soluble gases; passed through the biologically active mantle of the earth; and appeared as clean uncontaminated water.[40] The economic and technical potential of A.G.R. treatment systems result from their ability to virtually eliminate a host of difficult pollutants in a single process which is similar to the natural phenomenon just described. A.G.R. systems provide advanced wastewater treatment for biological and suspended matter, for nitrogen and phosphorous compounds, for detergents, for toxic heavy metals, and for bacteria and viruses.[41] The fact that A.G.R. treatment systems efficiently remove viruses from wastewaters merits additional discussion.

As stated previously, A.G.R. treatment systems remove virtually 100 percent of the viral contaminants in wastewaters. In contrast to this, the most widely used method of secondary treatment for domestic wastewaters, i.e., the activated sludge process, has been shown to be totally ineffective in removing viruses.[42] It is incapable of doing so. It is rather startling to realize that in light of the present medical evidence which suggests viruses cause many diseases such as mononucleous, infectous hepatitus, polio, the common cold, flu, lukemia, and other certain types of cancer, that the activated sludge treatment process is being advocated as the answer to the water quality problem which is plaguing the nation.[43] It is similarly startling to note that not one of the fifty states mention viruses of any kind in their approved water quality standards, and for that matter, neither does the Public Health Service's Drinking Water Standards, the federal counterpart to the states' water quality standards. In defense of this fact, however, one must realize the great difficulty inherent in isolating, measuring, and identifying these minute contaminants. The most significant fact to be drawn from this discussion, however, is that A.G.R. treatment systems can virtually eliminate all the viral contaminants from wastewater. This fact alone makes the use of the soil mantle as a treatment process virtually a necessity in the years ahead, for it does not take a particularly imaginative individual to see that the removal of such viral contaminants from a major source of water supply could significantly improve the overall health of our entire nation's populous.

An additional fact should be mentioned when contrasting the A.G.R. treatment systems with those in-plant systems presently being utilized. The present domestic wastewater treatment plants, as stated previously, do not remove viral contaminants contained therein, but only "inactivate" them. The "inactivation" process is of itself only questionably effective, because many microbiologists do not consider viruses to be complete lifeforms, but rather consider them only to be intermediaries of life which under proper physiological conditions can take control of living cells and direct their growth and activity. Accordingly, since the conventional means of wastewater treatment do not involve removal of viruses but only their inactivation, it truly makes the present practices questionable. In light of this fact as well, an increasing number of engineers, including this author, are inclined to follow the lead of Mr. Frank Stead[44] of the California Department of Public Health who states "that in view of the demonstrated ability of soil systems to remove bacteria and viruses, and the uncertainties of viral contamination, no water reclaimed from sewage should be considered for human consumption unless it has been first passed through the soil mantle of the earth or through some engineered system with similar characteristics."[45] It is patently obvious that the significance of A.G.R. treatment systems ability to remove viruses cannot be overemphasized.

Having drawn the proceeding conclusions, we should continue and evaluate the effectiveness of the overall in-plant treatment processes presently being utilized for wastewater treatment.

Dr. John R. Sheaffer,[46] cited earlier, has concluded that an appraisal of the effectiveness of the current pollution abatement methods demonstrates the need to formulate a new and comprehensive approach to wastewater management. It is his opinion that the present efforts are shortsighted, incrementally applied, and ineffective. The current in-plant approach is shortsighted because it does not look at the environment as a total entity, i.e., its air, water, and land as a single unit.[47] It does not operate as a closed system which recycles pollution back into the production cycle, but rather as an "open" one which for the most part discharges low quality effluents into flowing surface waters, thus passing them on to the downstream inhabitants. It is being only incrementally applied in piecemeal fashion because it attempts to treat each specific pollutant separately as it creeps up and becomes an environmental problem.[48] Finally, the present approach is failing as evidenced by the report from the General Accounting Office which concluded that the nation has spent over 5.4 billion dollars building over 9,000 waste treatment projects which have made very little improvement in the environment.[49] All this leads to but one conclusion, that the present treatment plant approach is not the one we should be using.

Dr. Sheaffer further concluded that our national policy and approach must change to a resource management approach which is a total environmental systems approach analagous to the one being studied in Muskegon County, Michigan.[50] Such a system operates as a "closed" system recycling much of our generated wastes back into the production of valuable resources. The

Muskegon Project, one type of A.G.R. treatment system, represents a resource management approach which can effectively reduce the whole range of wastewater pollutants because it encompasses a number of treatment mechanisms in one process. The approach recognizes that pollutants are merely resources out of place.[51] The soluble nitrogen, phosphorus, and potassium compounds in wastewater effluents discharged from the conventional plants cause excessive algal blooms in lakes, rivers, and streams, but which if discharged on the soil instead would represent the main elemental ingredients of fertilizer.[52] As was demonstrated earlier, A.G.R. treatment systems are capable of removing certain forms of soluble nitrogen and phosphorous compounds as well as various other pollutants from percolating wastewaters but conventional processes are not. These compounds when removed at the biologically active surface of the soil mantle become available as nutrients for plants.[53] Recall too, the possible synergistic effect involved, for marginal lands could be made agriculturally productive while solving a major wastewater disposal problem. It is not too unforeseeable that on a macroscopic scale vast semiarid and arid areas of the United States could be made agriculturally productive while providing a treatment and disposal mechanism for much of our industrial and domestic wastes, especially those generated in the heavily populated urban areas.

A.G.R. wastewater management systems of this nature appear to be feasible in virtually every urban area of the United States,[54] and their implementation would render the direct discharge of wastes into surface waters totally unnecessary. Here

too, it would not take a particularly imaginative scientist or engineer to foresee the possible effects of this as well. If the phosphorus and nitrogen rich discharges of even the secondarily treated effluents from conventional sewage treatment plants were halted, it is obvious that within a few years the recurring meteorological phenomenon of the hydrologic cycle would flush the rivers and streams in a manner which could virtually eliminate their present state of pollution, for the removal of these elemental fertilizing ingredients would relieve our nation's waters of one of their heaviest pollutional burdens. Although our lakes, streams and rivers may never return to their pristine state, they would be much healthier and more estheticly pleasing to the senses, and algal blooms could become nuisances of the past.

Dr. Sheaffer's final conclusion was that widespread adoption of the A.G.R. treatment systems approach would provide vision and direction for our nation's efforts to deal with water quality control for they advance a total environmental solution.[55]

Having concluded that A.G.R. treatment systems offer numerous potentially significant utilizations, the potential usefulness of A.G.R. non-treatment systems should be appraised. As stated in the previous subsection, A.G.R. non-treatment systems could offer a convenient and economical means of disposal of toxic and refractory wastes. However, it may also be one which is environmentally hazardous to future utilizations of the potable water-bearing aquifers underlying many area's of the United States.[56] The dangerous risks to the environment are the uncertain answers

to the question: To what extent might the proliferation of A.G.R. injection systems impair the utility of underground strata for the future extraction of groundwater or for the development of subsurface reservoirs for water supply storage and other purposes?[57] Research has begun and data is being collected, but with respect to the possibilities of environmental injury, at this time an assessment is inhibited by the sparcity of geohydrological knowledge and limited operating experience.

The dangers which have been associated with A.G.R. non-treatment systems include suspected earth tremors in the Denver area, as well as explosions in which the tops of injection wells have blown off because of the high pressures involved.[58] Frequently when these explosive mishaps occur, they are followed by gushing spills of wastewaters forced back to the surface by the great reduction in pressure at the pumping site.

Even in the light of the many dangers involved with A.G.R. injection systems, their potential of providing a means of disposal for toxic and refractory chemical contaminants is too significant to be summarily abandoned. It must be remembered that this method of disposal is relatively recent as regards the storage and disposal of noxious chemical pollutants. Perhaps the most significant conclusion to be drawn concerning A.G.R. non-treatment systems is the fact that the risks involved are as of yet most uncertain and the potential hazards may be very great. If the environmental hazards are found not to be materially significant, then A.G.R. storage and disposal systems will serve the nation's industrial sector to great advantage.

The general public as well will fill the impact of this economical means of disposal of industrial wastewaters reflected in lower prices for the products being produced.

One source indicates that subsurface well installation procedures and construction materials, developed by the petroleum industry, have the capability of providing the desired protection of the valuable groundwater resources, if properly used.[59] If this is so, then the principle question left for research to explore is the subterranean environmental effect sustained from deep-well injection of refractory chemical wastes. Until the question has been favorably answered, A.G.R. injection practices must not be permitted on other than purely research bases, and the expanding trend of the use of A.G.R. injection-wells must be halted.

Clearly there are many points of concern associated with both types of A.G.R. systems. Research must continue until all the uncertainties are resolved. Despite the risks, the potential for utilizing these systems which can in fact enhance the quality and quantity of this nation's water resources cannot be ignored. Where the A.G.R. treatment systems are employed, careful monitoring must be conducted. Evaluation and re-evaluation of the processes must be continued. Analysis of the data and evaluation of the processes will refine the operating practices, recommended guidelines, and ultimately the legislative regulations, which in return will yield a safer and more solubrious end-product, uncontaminated ground and surface waters throughout the entire nation. As regards those A.G.R. systems which employ the use of the ground

purely as a disposal-storage mechanism for toxic contaminants, not treating them in any manner except perhaps by dilution with subterranean waters, this practice cannot be permitted until a full disclosure of the environmental hazards has been made and until it has been demonstrated beyond a reasonable doubt to be safe.

The shortcomings of the present in-plant treatment processes currently being advocated as a solution to our surface and ground water quality problems have been pointed out, as have the numerous potential environmental advantages of the use of A.G.R. treatment systems. It is the A.G.R. treatment systems which offer the total environmental solution to our water pollution problems. It is these systems which must become the comprehensive new approach to wastewater treatment to be advocated and advanced throughout the nation. Accordingly, the allocated funds must be diverted from the construction of the more costly in-plant treatment processes to the less costly and more efficient A.G.R. treatment processes, because it has been estimated that by 1980, in the absence of drastic action to change our method of sewage disposal, the organic wastes imposed by human activity on the waters of the United States will require for their decomposition the total amount of oxygen contained in all the river systems of the nation in the summer months.[60] To environmental engineers and associated scientists, this prognostication, if accurate, would mean that each river in the nation would be reduced to a dark noxious flowing ooze of putrecence unable to support the vital physiological functions of fish, fowl, or other forms of wildlife.

It is, of course, totally incomprehensible that this would in fact be permitted to occur. The Congress of the United States and the legislatures of each state should take appropriate steps to implement and regulate A.G.R. practices for it is the duty of the respective state and federal legislators to keep pace with these technological advances. The time for action is now.

III. PART TWO: LEGAL CONSIDERATIONS

Having discussed, in Part One, on a macroscopic basis, the potential advantages and hazards associated with the utilization of A.G.R. systems, it is time to reorient our thoughts to the more microscopic or finite processes involved. More specifically, Part Two attempts to elaborate the legal problems involved with the utilization of A.G.R. systems. It stresses the various possible liabilities which could be incurred by anyone who attempts to use the process.

A. Private Ownership Versus Public Interest in Groundwaters

1. A Problem

The first legal question or problem which needs to be resolved is whether a non-overlying landowner has the right to use the subterranean storage space of another. It is a question, then, of who owns the underground or who can use the subterranean interstices for storage purposes.

The question arises because all A.G.R. systems utilize subterranean storage space but not necessarily only that storage

space beneath the actual recharge basins. In fact, they are designed normally to recharge a large and undefined general area of subterranean strata.

James H. Krieger stated at the Sixth Biennual Conference on Groundwater Recharge, Development and Management,[61] held at the University of California in September of 1967, that he felt this one question was the most pressing issue which had to be resolved before proper management of A.G.R. replenishment systems and groundwater basins in general could be affected. He pointed out several of the arguments pro and con concerning this legal question. One school of thought, he said, is that the underground space belongs to the overlying landowner. Under this theory, theoretically, an overlying landowner could keep anyone out of his underground space if he wanted to, or he could sell the space, or he could treat it like he would an oil and gas lease. Another school believes that the overlying political subdivision has control over the underground in behalf of all the overlying inhabitants. This theory would permit state regulation of the storage space through operation of law under the theory of the sovereign's inherent police power.[62] Still another school, with advocates primarily in the western appropriation states, feels that the underground is really a state resource to be shared by all the people exactly in the same manner as the water itself is shared, and if someone has surplus space, as he may have surplus water, perhaps then, that surplus space should be the subject of state control and regulation just like the water itself.

Mr. P. H. McGauhey[63] made an interesting comment in the final address at the conference. McGauhey said he was surprised at the consistent concern and expression of the various conferees for the maintenance of the integrity of individual landowners' groundwater rights, when at the same time, the majority of those same conferees repeatedly emphasized the fact that the management of ground and surface waters is inseparable. McGauhey said that there were several reasons why he personally believed that this inviolability of property rights in groundwater would one day disappear. For in as much as the property right in groundwater is based on scientifically unsound assumptions that the groundwater can be managed separately from the surface water, he stated that we are confronted with a truly serious dilemma. He continued stating that "certainly we cannot go on pretending that surface water belonging to the public becomes private property because streams have leaky bottoms and then, once again, becomes public property upon returning to the surface; or that it is not for the public to object when its 'property' ceases to exist part of the year because of the way individual citizens have managed it while the water was in its private phase."

The California conferees are not the only ones who have expressed concern over the question of subterranean ownership. Mr. J.S. Talbot, author of several related scientific and legal articles in this area, has urged clarification by legislative and regulatory bodies of the definition of subsurface "public" waters.[64]

In actuality, the question is a classic legal dilemma which is couched in terms of private ownership on one hand and the public interest in the vital resource, water, on the other. Real property

law doctrines generally state that one who holds title to real property owns an estate which includes everything beneath its surface to the center of the earth as well as everything reaching skyward above it. Contravening this legal principle is the recognized judicial limitation on the individuals' property rights which generally stated allows the sovereign to reasonably regulate its citizens and their property for the promotion in the public interest of the health and general welfare of all its citizens. Clearly, it is a judicial question which must balance or weigh the rights the individual has against those of the public-at-large.

The positions of both adverse interests are readily comprehendible. The individual wants free and uncurtailed use of the property which he owns. The state which represents all its citizens recognizes that to do a proper job of managing the essential natural resource water, it must regulate its surface and ground water supplies.

2. A Possible Solution

The most potentially reasonable and judicially acceptable solution to the question would entail a compromise between the conflicting legal doctrines and varying schools of thought mentioned earlier. The compromise solution would recognize the individual's ownership rights, but would permit the state to restrict these subterranean groundwater rights by allowing it to manage the groundwaters under color of the sovereign's inherent police powers. Accordingly, it is the opinion of this author, that the state can with proper legislative enactment permit and

regulate A.G.R. practices under its police powers without violation of the constitutionally protected property rights of the individual when done in the public interest for the promotion and protection of the health and general welfare of its inhabitants.

It should be emphasized, however, the state and/or federal sovereign's police powers in this regard are not totally absolute. The judicial branch of our government limits the exercise of the police power to reasonable and legitimate ends only, for otherwise the state would be violating the substantive due process and equal protection guaranties constitutionally provided every state and federal citizen.

It should also be emphasized that the suggested solution is not necessarily a complete solution. While it would allow the state to use and regulate A.G.R. practices, it would not offer an effective means to regulate the consumptive rights of the overlying landowners.[65] This is but another indication that the area of subterranean law is simply replete with conflicting legal doctrines. Although the legal principles of consumptive water law will be briefly mentioned in this article, this author is specifically avoiding any detailed discussion of the complex legal problems involved with such uses. It should be realized that while consumptive regulation may be necessary for effective basin-wide groundwater management, it actually represents the extraction of the waters recharged into a basin and, thus, rightly so, should be governed by substantially different legal principles than those which would apply to the replenishment of the

recharge water. Since the extraction and the replenishment of groundwater are processes essentially opposite to and independent of one another, the author chose to discuss the legal principles which may be involved with the replenishment half of the groundwater basin management problem. The law of consumptive rights having been with us much longer although varying from jurisdiction to jurisdiction has, at least, involved much litigation and much has been written on the subject particularly in the last decade. Within each jurisdiction, it is a reasonably settled question.

Before discussing the suggested, partial solution in more detail, a fine distinction in the "ownership" versus "permissible regulation" continuum must be raised. Rights, duties, and liabilities in respect to subterranean waters are sometimes regulated by statute, whereas the right of a landowner to gather and use percolating waters as he will even at times to his neighbors' detriment cannot be taken away from him unless by the exercise of the sovereign's eminent domain power.[66]

The distinction is this: When the state or federal government utilizes its eminent domain power, it "takes" property for a public purpose and pays full fair market value compensation for the taking, whereas, when the state or federal government utilizes its police powers, it "regulates" an activity for the purpose of protecting the health and general welfare of its citizenry. In the latter situations, there is no taking, and no compensation is required to be paid. Thus, even though an individual has his ownership of certain water rights restricted, it is

not a sufficient taking to embrace the necessity to pay full compensation. The courts have reduced the problem to a question of whether the act complained of by an aggrieved party is in fact a "taking" for which full compensation must be paid, or is a reasonable exercise of the states' constitutionally permitted police powers for the protection and promotion of the health of general welfare of its inhibitants.

An analogous situation exists where the state regulates private property through the enactment of zoning statutes and ordinances to protect its constituents' health and general welfare. So, too, it is the feeling of this author that the state can reasonably restrict through reasonable regulation the storage space beneath a man's real property for the purpose of providing in the public interest management to ensure ample quantity of good quality water for all its inhabitants. Although both zoning and A.G.R. regulations are or will be restrictive of individual rights of ownership, they do not and should not, respectively, entail a sufficient taking to engender applications of the eminent domain provisions of the federal and state constitutions.

Although this is but one man's opinion, let the author add one further caveat to the conclusion just drawn. It must be remembered that this issue is clearly a fact question which must be determined on the factual setting surrounding each case. It would be a doubtful opinion, indeed, if it were unequivocally stated that the utilization of an overlying landowner's subterranean storage space could never amount to a sufficient taking for which full compensation would have to be made. Such compensation would, however, involve extremely difficult valuation problems.

It should be noted that an application of this possible solution is not necessarily without substantial legal question itself, for the suggested basis for state regulation of groundwater makes no mention of two particular problem areas. It would, of course, work reasonably well where the overlying landowner is not actively using his underground storage space. The problem or conflict will arise when he is actually using his subsurface property for the recovery and extraction of groundwater or other valuable natural resources. Where actual active use is being put to the owner's property, there is substantial judicial precedent which holds that interference with these types of real property rights would amount to a "taking" in fact, and, thus, could only be restricted through the exercise of eminent domain. Note, however, this problem may not be too significant since it would probably be settled by application of "extractive or consumptive" legal doctrines as opposed to the more recent "replenishment" principles which are clearly still in their developmental stages.

As stated earlier, the utilization of the state's police powers to regulate A.G.R. practices would appear to be constitutional. It does not offer a complete solution for the management of intra-and inter-basin districts, however, for the replenishment of groundwaters is only part of the entire management necessary to maintain the essential water supplies. The California conferees were concerned also with the consumptive uses and water rights maintained by the overlying landowners, for if the consumptive uses of the water cannot be controlled, then the overall groundwaters of the basin cannot be properly managed.

This is a question which must be resolved. It will be the subject of much investigation and litigation in the years ahead. The law as it presently stands, states, as a general rule, that the landowner owns the percolating water beneath the surface of his property and this ownership concept allows him to do with his waters, generally whatever he wishes. Only through application of the state's eminent domain power, which provides for full compensation to a landowner for his water rights, can these water rights be taken from him. Accordingly, much of the complex legal problem associated with the management of the consumptive use of a groundwater basin remains unsettled and will remain so, even after A.G.R. regulation is firmly established as being within the auspices of a state's police powers.

B. Scope of State's Police Powers

Having stated a major legal problem and tendered a partial solution to it, it becomes appropriate to turn our attention to how the courts have reacted when faced with similar situations which question the constitutionality of the exercise of the state's police powers.

States clearly have the power to regulate water supply waters, particularly in the area of pollution control. In cases dealing with surface waters, it has been said the state may adopt and enforce appropriate methods of protection of the waters thereof from pollution.[67] Many states have expressly forbidden the pollution of streams or bodies of water therein, and have enacted statutes which make violations of such statutes indictable offenses punishable by fine or imprisonment.[68] Such statutes are generally

held to be valid exercise of the police power of the state, and not objectionable as a taking of private property for a public use.[69] It should also be noted that such regulatory authority of the state can be delegated to municipal corporations as well.[70] Accordingly, this author can see no reason why such regulation should not and will not be extended to groundwater for its protection from pollution and for its optimization in overall management.

The court in Shirley v. New Hampshire Water Pollution Comm'n.,[71] stated by way of dictum the general proposition that the control and elimination of water pollution is a subject clearly within the scope of the police power, that the tendency of its control to promote the public health and welfare cannot seriously be questioned, and that a statute for such purpose is normally to be sustained as constitutional. Similarly, in upholding the validity of a state anti-water pollution statute as being within the proper auspices of the police power, the court in Cooper v. State[72] stated that constitutional provisions against taking property for a public purpose without just compensation imposed no barrier to the proper exercise of the state's police power.

It seems apparent then, that the state can through proper legislative enactment regulate A.G.R. practices under the color of the state's police power for the purpose of protecting and promoting the health and general welfare of its inhabitants without it amounting to an eminent domain "taking" in most situations.

Of significance, also, is the fact that normally general anti-water pollution enactments do not preclude the utilization of other remedies which would otherwise be available to those sustaining legal injury. In Williams v. Pendleton Mfg. Co.,[73] a state anti-water pollution statute was held irrelevant in an action brought by one riparian owner against another for causing the death of his cattle because the latter had polluted a creek. Such statutes do not strip the courts of their historic jurisdiction to determine whether pollution, in fact, exists by conferring that power exclusively upon an administrative agency. Note, however, at times even where a statute has been held not to have abolished the common law right of action for wrongful water pollution, some courts have held the "primary administrative jurisdiction rule" applicable.[74] When this rule is applied, the judicial proceeding is suspended pending administrative determination of certain technical or scientific questions of fact. Once these questions are resolved by the agency, the judicial proceedings under the common law cause of action are once again continued.

In conclusion, the overlying property owner who is not actively using the subsurface of his land should have no real or justified complaint in having his subterranean storage space utilized when done for a public purpose with the intent to manage the vital resource groundwater on a basin-wide basis. In those cases, where he is actually extracting groundwater or other valuable resources in a bona fide enterprise, the state must recognize these active property rights when attempting to regulate the

overall groundwaters of a basin, for should it interfere with or obstruct these protected property rights, the landowner would clearly have a cause of action against the state's acts of infringement.

C. Private Remedies

Having discussed some of the legal problems associated with subterranean ownership and regulation which the courts will have to contend with in the not too distant future when A.G.R. systems become widely utilized, it next becomes appropriate to consider a question which the remaining portion of Part Two will concern itself with. The question is: Exactly when would the regulated overlying landowner have reasonable grounds to complain of violations of his constitutionally protected groundwater and related property rights?

Normally, the landowner has grounds to take judicial action when violations of such rights arise in three general areas. The first area involves interferences, diversions, or obstructions of his rights of utilization. These rights could be classified as consumptive causes of action. The courts historically have resolved questions which arise when one landowner sinks a well too close to another and draws down the latter's well or when one landowner takes more than his share of the groundwater, or when all the consumers exceed the safe-yield of the basin. These consumptive causes of action will only be discussed briefly in general terms as A.G.R. practices will not directly affect the consumptive rights of the landowners, for, indeed, A.G.R.

treatment operations will actually increase the landowner's consumable groundwaters.[75] The second general ground for judicial complaint arises when pollution damages are sustained and a detailed discussion of this direct potential hazard from A.G.R. operations is included herein. The final general area of possible litigation may arise from adverse drainage or flooding problems associated with A.G.R. treatment systems. Typical examples of this cause of action would arise when one has had his cellar flooded or crops destroyed because of an adverse effect on the usual drainage pattern of the area.

1. Interferences, Diversions, and Obstructions

Groundwater has often been divided into legal classifications of underground streams and percolating waters. Each have different legal consequences, even though hydrologists emphasize that these classes are not distinct but closely inter-related.[76] Underground streams are classified on the basis that they flow in fixed or definite channels, whereas percolating waters are defined as those subsurface waters which, without any permanent, distinct, or definite channels, percolate in veins or filter through the lands of one owner to those of another.[77] The significance of the separate classifications is this. It is generally agreed that the riparian and prior appropriation doctrines governing surface water courses are equally applicable to subterranean streams; whereas different legal doctrines may govern the consumptive rights of landowners in percolating waters. In essence, this means that there may be different laws applicable to the consumptive utilizations of a landowner depending on whether he

is extracting his water from an underground stream or from the more frequently encountered percolating water. It will be shown later that this classification of groundwaters as an underground stream or merely percolating water may also affect the applicable law regarding subsurface water pollution in a few jurisdictions. This paper intending to deal with the more general situation relies on the legal presumption, alluded to above, that most groundwaters are percolating,[78] and, thus, limits itself to discussions of the legal problems associated with percolating waters.

In the cases dealing with liability for the interference, diversion, or obstruction of groundwaters in the use of one's own premises, such liability or immunity therefrom, has usually been based, in the absence of contract or statute, on one or both of the fundamental principles governing the rights and liabilities as between adjoining or neighboring landowners generally. One of these principles is that the owner of the soil owns everything above or below the surface, upward to the sky and downward to the center of the earth, expressed in the maximum "cujus set solum, ejus est usque ad coelum et ad inferos." The other principle is that man must so use his own property as not to injure another, expressed in the maxim "sic utere tuo ut alienum non laedas." Some courts have applied or emphasized one of these principles to the exclusion or minimization of the other, while others have sought to give effect to both in harmony.[79] The former rule, known as the common law or English rule, in effect states that at least in the absence of negligence or malice, any obstruction, interference, or diversion of the percolating waters

by an owner or occupant of land incident to a use thereon to the injury or detriment of an adjoining or neighboring owner is damnum absque injuria, i.e., there is no liability in the absence of a showing of negligence. The latter principle, known as the reasonable use rule or American rule, limits a landowner's use to beneficial purposes which have a reasonable relationship to the use of the overlying land. It will suffice to say that depending on the courts' selection of which classification of subterranean water is being affected, the legal consequences involved by these distinctions can lead to significantly different judicial decisions in different jurisdictions.

With the preceding as background discussion emphasizing some of the complex legal problems associated with consumptive water rights, the author turns his discussion to those legal problems which could more directly arise out of the improper utilization of A.G.R. treatment and non-treatment systems.

2. Pollution

The attractiveness of A.G.R. systems, whether utilized for waste disposal, water storage, or wastewater treatment, is complicated by significant social and legal considerations. Of primary concern is the pollution potential and its legal consequences should it occur due to improper management of or malfunctions in the system's operations.

The pollution of subterranean waters has been the subject of much consideration by the courts over the years. Generally, the rights and liabilities of the parties are the same whether such waters are percolating or are in fixed streams following

defined courses.[80] There are, however, a few cases in which it has been held or recognized that while an owner might pollute a subterranean stream, he should not contaminate percolating waters, So, too, are there cases which have held that an overlying landowner may pollute his percolating waters but not subterranean streams. These conflicting minority positions are included herein only to demonstrate that in a given groundwater pollution case several possible outcomes could be reached, depending upon the jurisdiction in which the cause of action arises.

As a corollary to the theory mentioned earlier, that percolating water is to be regarded for all purposes as a part of the containing soil, and that the owner of the land has the absolute right to make whatever use of it he sees fit, without incurring liability to anyone thereby injured,[81] some courts have held that such owner is exempt from legal responsibility even if from his act contamination results to the underground water upon a neighbor's premises.[82] Most courts and legal commentators, however, recognize the right of pollution to be a matter controlled by different considerations from the right of a landowner to injure a neighboring owner by diminishing the supply of subterranean water by either a reasonable or unreasonable use;[83] and the weight of authority supports the rule that one who, by acts done or permitted on his own premises, causes the pollution of percolating waters to the injury of the springs, wells, or premises of neighboring proprietors may be required to respond in money damages, and that such pollution may, in a proper case, be prevented by injunction.[84] Some of the decisions taking this view

expressly hold that the landowner, notwithstanding his right to make an appropriation of all the underground water, and, thus, prevent its use by another, has no right to pollute, contaminate, or poison it however innocently, so that when it reaches his neighbor's land, it is in such condition as to be unfit for use, either by man or beast.[85]

Accordingly, individuals aggrieved by the improper operation and maintenance of A.G.R. systems have remedies available in the courts. Normally, the private remedies available for pollution damage are sought by way of tort actions for violations of one's protected civil rights. Recoveries, whether seeking monetary damages or injunctive relief, have generally been based on one or more of the following tort theories: Negligence, nuisance, strict liability, or trespass, depending upon the particular jurisdiction in which the action was brought.

Before discussing each of these four respective tort theories, it may be worthwhile to briefly discuss the various types of remedies available to aggrieved parties, who have sustained pollution damage. The types of relief obtainable for an injured person from a tort or civil wrong are usually either an award of money damages or the issuance of an injunction to restrain and prohibit the wrongful act.[86] At times, both types of relief are recoverable.

a. Types of Relief

1) Injunctions

Assuming a cause of action exists under one of the four theories mentioned above, the preferred type of relief against

a tortious violation of one's groundwater rights may be the injunction rather than an action for money damages, because injunctive relief may be prohibitive and can furnish relief before, instead of after, a threatened violation. It should be noted, however, that if injunctive relief is available, damages for past harm may also be obtainable as an adjunct to the injunction in the equity suit. The theoretical prerequisites necessary to obtain this extraordinary remedy appear to place a formidable burden of proof upon the plaintiff, for he must show from the facts of the case that the threatened injury is irreparable or one that cannot be adequately compensated for by an action at law; or that if the injunction is denied, a multiplicity of law suits would result.[87] The courts, however, rarely consider these prerequisites to injunctive relief separately. Rather, it seems clear that they react similar to the situation arising in the case of Boise Dev. Co. v. Idaho Trust and Savings Bank,[88] in which the court stated in substance, that to warrant a permanent injunction, there must be a showing of real and imminent danger of damage. The threatened injury must be material and actual. An action cannot be granted to allay the fears and apprehensions the complainants have as to what may occur in the future. It is incumbent upon complainants to show that the acts against which they ask protection are not only threatened, but will, in all probability, be committed to their permanent injury. Accordingly, then, to obtain injunctive relief, the injury must be material and actual, and not fanciful, theoretical, or merely possible.

Before turning our attention to a brief discussion of the monetary damages possibly recoverable, it is important to mention a significant limitation frequently encountered by those attempting to obtain an injunction. The limitation is the balance of convenience doctrine.[89] Courts, in using this doctrine, weigh the relative interests of the defendant, the plaintiff, and the public as a whole and may deny the injunction on the ground that the public interest in permitting the wrongful act is of overriding importance even though the plaintiff was clearly damaged and the defendent's action was otherwise tortious.

2) Monetary Damages

Little need be said about recoveries and awards of monetary damages, other than to mention that the common law measure of damages for violations of one's groundwater rights depends upon both the nature and extent of the injury sustained. The identification of an injury as permanent or temporary will determine the manner in which the damages may be collected. If the injury is classified as permanent, there can be only one action, and all damages past, present, and future must be recovered therein.[90] In contrast, if the injury is classified as only temporary, recovery is allowed only until the time of suit and successive recoveries in subsequent actions are permitted if the injury continues.[91]

In conclusion, one final point may merit mention. At times it may be strategically wise for a plaintiff to seek monetary damages even though the provable injury may be so small that the

judgment for damages would not be of any real financial value. The judgment, however financially worthless, could itself be valuable as a means of preventing the gaining by the defendant of a prescriptive right to pollute plaintiff's groundwaters. The defense of a prescriptive right to pollute is discussed in a later portion of this subsection.

Having discussed the various types of remedies available, it now becomes appropriate to discuss the various elements of each of the four major causes of action through which these remedies are judicially obtainable. The causes of action are discussed in the order of their present significance with those most frequently utilized being described first.

b. Legal Causes of Action

1) Negligence

The two most widely accepted bases for relief in the contamination of percolating waters are the distinct and separate torts of negligence and nuisance. The tort of negligence arises when one fails to use the degree of care required under a particular situation. The legal standard of care required is that which would be exercised by an ordinary, reasonable man acting under like circumstances.[92] In most situations it is a jury question to be resolved on the facts of each individual case, and the plaintiff complainant has the burden of proof for all the elements of the tort.

In Trillingham v. Alaska Housing Authority,[93] in which an action was brought to enjoin the defendant from continuing to pollute and diminish the plaintiff's supply of percolating waters

and also to recover monetary damages, the court stated that two views had been taken in dealing with the pollution of percolating waters: (1) absolute liability (this theory will be discussed in a following section as strict liability), and (2) liability based on negligence. The court, in finding for the plaintiff, stated that it favored the latter rule since it appeared to be better adapted to growing communities.

In a factually similar case arising ten years after Trillingham, a Pennsylvania court in Reinhart v. Lancaster Area Refuse Authority[94] concurred with the Trillingham court and articulated the various elements necessary under a negligence theory. The court said that the action fell into the category known as a non-trespassory invasion of another's interest in the private use and enjoyment of land. The tort arises if a.) the other has property rights and privileges in respect to the use or enjoyment interfered with (i.e., plaintiff's groundwater was polluted); and b.) the invasion was substantial (i.e., plaintiff's groundwater was substantially polluted); and c.) the actor's conduct is a legal cause of the invasion (i.e., the defendant did it); d.) the invasion is either (i) intentional and unreasonable; or (ii) unintentional and otherwise actionable under the rules governing liability for negligent, reckless, or ultra-hazardess conduct.

In reaching its decision, the Reinhart court essentially adopted the position taken by the American Law Institute's Restatement of Torts.[95] The liability for interference with the subterranean waters in the use of one's own property, to the injury of another, is determined by the rules governing liability

for non-trespassory invasions of interests in the private use and enjoyment of land generally.[96] The Restatement's position, then, more specifically is that such liability depends upon whether the causative activity or conduct 1.) if intentional, was unreasonable, or, 2.) if unintentional, was negligent, reckless, or ultra-hazardess. As adopted in the Reinhart and Trillingham cases, the Restatement's rules represent what appear to be a most reasonable, logical and practical approach to solving the legal problems associated with the contamination of percolating waters.

2) Nuisance

The second of the two most widely accepted bases for relief for the pollution of percolating waters is the tort of nuisance. Nuisance is any conduct that interferes unreasonably and substantially with the enjoyment of the possession of land.[97] Again, note a distinction, negligence arises when one fails to use the degree of care required under a particular situation, whereas nuisance does not rest on the degree of care used, but on degree of unreasonable interference with another's property right when one acts even with the best of care.

The theory of nuisance is applied to underground waters as a cause of action for primarily three reasons: (1) the owner of the land is entitled to the use of the underground water in its natural state, (2) his adjoining landowners have no right to limit this use, and (3) the pollution of the underground waters would change the natural state and prohibit his use thereof.[98]

As with negligence and most other torts, the party seeking relief under the theory of nuisance must prove the nuisance exists and that actual damages were sustained. These burdens of proof were met in the case of Gulf Oil Corp. v. Hughes,[99] in which the pollution of a well by encroaching secondary recovery waters from an A.G.R. non-treatment system was found to be a nuisance.

The cause of action nuisance is also subject to the equitable defense of balancing of convenience or the public interest doctrine. As stated earlier, under this doctrine the courts weigh the resulting damages which would be incurred by the public generally as well as the parties involved to determine whether or not they will sustain the plaintiff's petition for injunctive relief. In the case of Pennsylvania Coal Co. v. Sanderson,[100] injunctive relief was denied a plaintiff complaining under a nuisance theory primarily on the grounds of the balancing of convenience doctrine.

3) Strict Liability

The third theory by which recovery through tort litigation can be had is via the doctrine of strict liability. This doctrine is perhaps the most interesting doctrine of all those expressed because it is the newest theory under which recovery can be gained. The doctrine was initially expressed in 1866 in the English case of Rylands v. Fletcher,[101] which established that a person should be obligated to make good any and all damages resulting from the escape of something onto a neighbor's property that is ordinarily harmless to others as long as it is confined on that person's own property. This theory is significantly different that the other theories discussed as grounds for recovery due to groundwater

pollution for it contends that fault is not a prerequisite for liability. Presently, the doctrine of Rylands v. Fletcher has been expanded to arise in those situations where the conduct complained of is socially desirable but the danger which it threatens to others is unusually great, even though the activity is conducted with every possible precaution.[102] Herein, the basis of liability lies, for the defendant is held liable for the unusual gravity of the risks of an act which in itself is regarded as reasonable. Accordingly, the basis of liability is his intentional behavior in exposing the community to such a grave risk.

The court in Belvidere Gas Light and Fuel Co. v. Jackson,[103] stated, in applying a strict liability theory to the pollution of a well, that neither negligence or nuisance were necessary in order to render the defendant liable. The Illinois court stated "the fact that a business is conducted with all reasonable care to prevent injury to the rights of others will not itself relieve the proprietor of responsibility if an injury actually results therefrom to others." This same theory was used in rendering the defendant liable for water pollution in the case of Klassen v. Central Kansas Co-Op Creamery Assoc.[104]

It should be noted that not all states have accepted the strict liability doctrine. Many courts which have expressly rejected Rylands v. Fletcher by name, however, have imposed its principles for such activities as blasting, drilling oil wells, and other potentially hazardous enterprises.[105] Accordingly, these jurisdictions may categorize underground disposals of

domestic or chemical effluents by A.G.R. systems as potentially hazardous activities. Thus, in those jurisdictions in which they are so categorized, those individuals which utilize A.G.R. operations will be subject to this the most strict legal cause of action through which recovery can be obtained.

Perhaps the most significant relatively recent court decision shedding light directly on this point was rendered in the case City of Los Angeles v. City of Glendale.[106] In this case, a California court indicated by way of dictum that an importer and user of an A.G.R. water storage system should have the responsibility for any and all damages and losses sustained by anyone affected by its operation. Thus, it would appear that there is at least persuasive precedent that A.G.R. practices may in time be subject to the austere constraint of the strict liability doctrine.

In concluding the discussion on strict liability, it may be worthwhile to add that W. L. Prosser, a recognized authority on tort law, feels that there is an increased tendency by the courts to accept this doctrine. In fact, he prognosticates that it will become firmly established in American tort law within the next four or five decades.[107]

4) Trespass

The least utilized theory of recovery for subterranean water pollution is the theory of trespass, because of the numerous inherent difficulties associated with its proof. It may, however, in clear cases be utilized as a means of recovery.

Trespass is defined as the unauthorized entry on the lands or an invasion of the property rights of another.[108] As with the other theories mentioned, recovery is allowed only when the plaintiff can demonstrate that actual damages were sustained and can identify the offending party. These requirements along with the basic elements of trespass, possession and an intentional act, must be shown to obtain recovery under this theory. Each of these requisites are at times difficult to establish in subsurface trespass cases and accordingly, limit the utilization of trespass as a theory for recovery.

An interesting aside to this subsection on subterranean trespass deals with a problem alluded to earlier in Part Two which dealt with the question of subterranean ownership. Legal problems arising in the oil and gas industry have produced the rule of capture, which enables a well operator to claim as his own any oil or gas that migrates from adjoining lands to a well sunk in his own land.[109] W. B. Smith[110] has suggested that because of the widespread introduction of water injection for secondary recovery of oil, a negative rule of capture is apparently developing. It is arguable that since a well operator can withdraw fluids that migrate from adjacent lands to his land, that by applying reverse rationale, he should also be entitled to inject material that will migrate through the subterranean strata into lands belonging to others. Thus, it would appear that this rationale would also permit A.G.R. practices, but however, would not offer a defense for resulting pollution damage to any of the aforementioned theories of recovery.

5) Statutory Violations

Another means through which relief may be obtained is when the resulting pollution from an A.G.R. system violates a specific statute. As discussed earlier, the states and the federal government each respectively have substantial constitutional powers to enact anti-pollution laws which regulate, control, and prohibit activities declared to be a menace to the public health, safety, or general welfare.[111]

The effect of such statutory violations can be felt in two ways. First, in many of the states the pollution of streams and bodies of water is expressly forbidden by statute and a violation of such statute is made an indictable offense, punishable by fine or imprisonment.[112] Second, and of no less significance than the possibility of criminal prosecution for anti-pollution statute violations, is the fact that the courts can and often do impute civil liability for violations of certain regulatory enactments. For example, in Turner v. Big Lake Oil Co.,[113] the court after finding the defendant had violated Rule 20 of the Texas Railroad Commission which prohibited the pollution of underground waters, found that this violation was also a violation of a state pollution statute and held the defendant civilly liable for damages through application of the theory of strict liability. Similarly, violations of regulations established by state administrative bodies have been deemed to impose liability as constituting negligence per se.[114]

c. General Defenses

In addition to the equitable defense of the public interest doctrine to suits for injunctive relief in nuisance actions, discussed earlier, there are other general defenses to the various causes of action discussed above. These other general defenses are the subject of next portion of Part Two.

1) Act of God

A major defense applied by many courts involves the Act of God principle. Under certain circumstances, an independent intervening force of nature, i.e., an Act of God, may absolve a party from liability. The rationale behind this legal principle is the fact that the common law normally required a reasonable and continuous chain of causation between the acts of the defendant and the damages sustained by the plaintiff as a result of those acts.[115]

This principle is not uniformly adopted throughout the numerous jurisdictions, nor is it even uniformly applied in those jurisdictions which have adopted it. For example, while it does normally absolve a party from liability under tort litigation involving strict liability actions where there was an unforeseeable intervening force of nature, it does not relieve one from liability under the theory of negligence if foreseeable results occur from unforeseeable Acts of God. Clearly, this is a close and difficult legal distinction, one which may best be understood by considering a hypothetical example. Recall from Part One, earth tremors were thought to be caused by an A.G.R. non-treatment disposal system which was operated in the Denver,

Colorado area. If litigation were subsequently to involve earthquake damages which were alledgedly caused by a deep-well disposal system similar to the one installed and operated in the Denver, Colorado area, then by pointing out the previous possible earth tremors of that region of the country, it might be concluded by a court that such earthquakes are foreseeable when utilizing A.G.R. non-treatment systems. Hence, they would not be unforeseeable Acts of God associated with such A.G.R. operations and a court could find that liability would result through a reasonable and continuous chain of causation commencing from the activity of deep-well disposal to the damages sustained by the plaintiff caused by a potential earthquake. This specific hypothetical example remains, of course, open to conjecture. However, it does serve as a basis for comprehending the courts' reluctance to uniformly apply the Act of God defense even in those jurisdictions where it has been accepted.

It should be reemphasized that the liability in such cases turns purely on the question of foreseeability. If the results were reasonably foreseeable when the defendant undertook the enterprise, then the Act of God principle will be inapplicable in his defense.

2) Prescriptive Right to Pollute

A second major defense which a defendant may allege particularly in nuisance cases is that he has gained a prescriptive right to pollute.[116] This defense, while used frequently prior to the increased awareness to the hazards of environmental pollution, has been sharply curtailed and limited in application by

the courts in recent years.[117] A prescriptive right to pollute may be gained only so long as it is private in nature, for cases have held that a prescriptive right cannot be gained in public nuisance situations.[118] It should be noted, however, that once a prescriptive right is gained, it may not be taken or denied unless through application of the state's power of eminent domain.

[3) Damnum Absque Injuria]

Another interesting, yet limitedly accepted, principle, though not a defense in the true sense of the word, involves the doctrine of damnum absque injuria, which means "no loss or damage without a violation of a legal right." In essence, the principle means that there is no liability if the defendant's act is a lawful one regardless of whether relief is sought on the theory of negligence, nuisance, or trespass. The jurisdictions which support the doctrine hold that in order to gain recovery, negligence must be shown, for even in the event of damage in the absence of a showing of negligence, there is no liability.

The principle is most clearly stated in the Rhinehart[119] case cited earlier. The court stated that it well recognized the universal principle that every man has the right to a natural, proper, and profitable use of his own land, and if, in the course of such use without negligence, unavoidable loss is brought upon his neighbor, it is damnum absque injuria.

The classic case of United Fuel Gas Co. v. Sawyers,[120] which applied the damnum doctrine, ties much of what has been discussed in this section of the paper together. Applying the "American rule" that in the absence of negligence there is no liability if

there is a legitimate and reasonable use of the defendant's property, rather than the common law rule that one must in all events so use his property as not to injure the legal rights of his neighbor, the court held that the drilling and casing of defendant's gas well in an approved manner and by proper methods did not constitute negligence or a nuisance, so as to render the defendant liable for the pollution of the plaintiff's water well, 450 feet away. The court pointed out that under the American rule, the owner of property may use percolating waters beneath its surface for all purposes properly connected with the use, enjoyment, and development of the land itself, but he is forbidden to use it for purposes not connected with the beneficial enjoyment of the ownership. Discussing the possibility of the existence of a nuisance, the court conceded that while a gas and oil producer is entitled to make any use of his property that is reasonable and lawful, he may not make such operations a nuisance. It pointed out that the land was being used in a legitimate manner, the hole was being drilled for a necessary and useful purpose, there was nothing to show that the injury to the plaintiff's water well should have been foreseen, and no question of malice or waste was raised. Assuming that there was a causal connection between the drilling of the gas well and altered condition of the water well, the court said that the only evidence was a legitimate and legal use of the property by the defendant which "incidentally" caused the plaintiff's water well to be contaminated with natural substances; also, that if the correlative rights of the plaintiff in the percolating waters, i.e., to have them kept pure for his use, was violated, it was damnum absque injuria.

It should be noted that by factual implication, due to the similar fact setting of this case with certain A.G.R. practices, that quite possibly the doctrine of damnum absque injuria could be applied to A.G.R. operations in those jurisdictions which accept it.

In concluding the discussion of the damnum principle, it is worthwhile to mention that there would be numerous instances in which it would not affect the consequences of litigation. Specifically, in those cases which involve the tort of negligence, defendant's negligence must be proven before recovery can be gained under the theory in the first place. Of course, then, if the negligence is proven, the doctrine of damnum absque injuria would be totally irrelevant.

Thus, there are situations arising in these particular jurisdictions where injury is incurred but recovery denied where the same set of facts would permit recovery in those jurisdictions not proclaiming and utilizing the damnum doctrine.

4) Statute of Limitations

The final defense which may be of significance involves what is known as the running of the statute of (time) limitation. Normally, however, this defense does not create a great problem to the complainant of pollution damages, because the majority of cases indicate that although it often may take years to discover that subsurface pollution has, in fact, occurred, the statute of limitations for commencing an action does not start to run until the pollution or its effects are discovered.[121]

Accordingly, tort litigation may be limited in its effectiveness by statutes of limitation which vary from jurisdiction to jurisdiction, if the actions are not timely brought once the pollutional effects are recognized by the injured party.

d. Liabilities of Municipalities

Having discussed the potential liabilities incurrable by private parties utilizing A.G.R. systems, it is appropriate to conclude the discussion by briefly mentioning the potential liability of municipalities. The fact that the pollution of subterranean waters is caused by a municipal sewer or some other municipal activity, e.g., a municipal A.G.R. treatment system perhaps, rather than by an act of a private individual or corporation has been held not to excuse the city from liability for such contamination.[122] In such cases, both money damages and injunctive relief have been judicially granted, just as they were in suits solely between private parties.

A Missouri court affirmed a judgment for the plaintiff in an action to recover damages for the pollution of the plaintiff's spring and lake, in Windle v. Springfield,[123] where it was shown that sewage flowing through a municipal sewer percolated through the adjacent soil and contaminated the plaintiff's spring and lake rendering the waters unfit for domestic or other uses. Although recognizing that under certain circumstances a municipality may be immune from suit,[124] the court concluded that the conditions under which the leaky sewer was installed caused a positive and direct invasion of the plaintiff's property by

percolating the soil in such a manner as to contaminate the owner's water to such an extent as to render it unfit for use. Accordingly, it held the city liable in an action for damages arising from the injury.

Similarly, in Ulmen v. Mt. Angel,[125] a defendant municipality was enjoined from draining the water from its streets into a gully from which seepage contaminated plaintiff's well.

Thus, it is apparent that municipalities and private individuals which utilize A.G.R. systems will be held to the same standards of pollution liability. Each will be subject to monetary damages and/or injunctive relief. Moreover, there are no grounds to conclude that such liability would only be extended to pollutional causes of action. Any cause of action plaintiff could reasonably raise with respect to the municipal operation of A.G.R. treatment systems would not likely be held immune from liability.

3. Drainage and Flooding

It is apparent that there are other potential hazards associated with the improper management of A.G.R. treatment and non-treatment systems. One such hazard could encompass interference with adjoining subterranean drainage patterns, while another could involve potential flooding problems. The rules governing liability for the obstruction or diversion of percolating waters have been applied in several instances where the injury complained of was the obstruction of the drainage of such waters from, or the diversion thereof into or upon, adjoining or neighboring premises.[126]

In Harwood v. Benton,[127] in which it was held that the defendant, who had a legal right to maintain a pond of water upon his land, and who by building a dam, produced a greater weight of water in his pond and thereby prevented subterranean waters from draining from the land of an adjoining proprietor was not liable when such water flooded a spring and was forced upto the surface of the adjoining land. The court stated, "No reason occurs to us why a party should be liable for the result of acts upon his land which impede the flowing of underground currents from the land of the adjoining owner, thus, producing injury, when it is conceded that he would not be liable for acts that would produce injury by preventing the flow of such current into the territory of such adjoining owner; why it is less unlawful for my neighbor to drain my well by digging one nearer mine, on his own soil, than to flood my cellar by the obstruction of a wall or other impediment that prevents the flow of water underground from my premises."

In other cases, it has been held that the defendant was liable or might be found so for the obstruction or flooding complained of. For example, in the factually similar case of Wilson v. New Bedford,[128] the defendant's impoundment was held to have obstructed the drainage of percolating water from the premises of an adjoining landowner, causing it to flood the cellars of buildings thereon, to plaintiff's injury. The court distinguished the case from others in which the rule of immunity from liability for interference with percolating waters had been applied, in that the injury resulted from percolation artificially caused by the impounding of water on the premises of the defendant, thus, bringing it

within the operation of the strict liability doctrine of Rylands v. Fletcher.[129]

Thus, the law as respects the subterranean rights of action associated with drainage and flooding problems is relatively open. The cases on point appear to be substantially split.

D. Legal Summary and Conclusion

Part One explored many of the significant advantages offered by A.G.R. utilizations and warned of the numerous potential hazards should the operations go on inadequately regulated. Part Two has examined the legal complications associated with A.G.R. use and regulation in light of the well recognized fact that surface and ground waters cannot be properly managed, separately. There are difficulties, of course, which must be overcome to allow the simultaneous management of each by the same regulatory authority. Such a regulatory scheme would optimize the total management of the essential water supply sources, surface and ground, while also effectively policing the closely related ancillary problems associated with wastewater treatment and disposal.

Part Two, subsection A explored the complex legal dilemma couched in terms of private ownership versus the public interest in groundwaters. It concluded that while private landowners do have certain vested ownership rights in their groundwaters and subterranean property; so, too, the state has constitutional authority to promote and protect the health and general welfare of its citizens. Although the private landowners may have their

ownership rights restricted somewhat, the state should validly be able to use and regulate A.G.R. systems in order to manage the groundwaters of the state. Accordingly, legislative enactments could provide total, uniform, and optimum water supply and wastewater disposal management, since falling clearly with the auspices of the state's inherent police powers.

This, by no means, leaves the private landowners without judicial redress should they sustain injury from a malfunctioning or mismanaged A.G.R. system which adjoins their property. State regulation of A.G.R. practices will not preclude private individuals from seeking monetary damages or injunctive relief regardless of whether the operation is conducted as a private or municipal enterprise.

The most common causes of action would arise from pollution, drainage, or flooding problems. In such cases, aggrieved parties may seek relief under various theories of liability, including: negligence, nuisance, strict liability, and trespass. Interferences with private consumptive rights would also be grounds for litigation under the principle of eminent domain, particularly where A.G.R. operations adversely affect the extraction of groundwaters or other valuable resources. Clearly, landowners adjoining A.G.R. facilities are protected with adequate remedies at law.

Where the state properly regulates the A.G.R. treatment and non-treatment operations, few problems should arise. By allowing the state to do so, however, it should clearly be able to integrate groundwater and surface water regulation, with

the net effect of better and more effective management of our vital water resources.

IV. PART THREE: PRESENT LEGISLATION

A. State Legislation

1. Introduction

It is appropriate to next review the status of the present legislative treatment of A.G.R. practices. This section shall discuss both the problems and advantages associated with present legislation pertinent to A.G.R. operations.

Many of the following introductory conclusions were drawn from a survey taken by Walker and Stewart[130] in 1968 which was expanded upon by Cleary and Warner[131] in 1969.

a. Administrative Agencies

The first question to be considered is what state agencies control groundwater pollution or otherwise affect groundwater regulation. Many states, at least in part, have vested some authority with their respective departments of public health.[132] The controlling authorities in other states are the state pollution control commissions.[133] Still other states vest the regulatory authority with their state departments of water resources.[134] State oil and gas conservation commissions play a significant role in groundwater regulation in several states. Other state agencies charged with certain responsibilities in the area of groundwater regulation include state water quality [control] boards, state geological surveys, state departments of

conservation, state stream sanitation commissions, state sanitary water boards, and state railroad commissions.[136] Of those states cited herein, many if not most, utilize several of the various state agencies to affect groundwater regulation.

Herein lies one of the major problem areas under the present means of groundwater regulation. In most states, there is no one centralized administrative agency charged with the uniform regulation of groundwaters. For example, the Final Report: Recommended Changes in Water Quality Control[137] took cognizance of all of California's agencies which were involved in some manner with the quality of its water resources prior to the enactment of the Porter-Cologne Water Quality Control Act[138] in 1970. The report mentioned the Department of Water Resources; Department of Public Health, Division of Environmental Sanitation; Department of Fish and Game; Department of Agriculture; Department of Parks and Recreation; Department of Conservation; California Water Commission; and the Colorado River Board. Clearly, such diversity can not help but create administrative nightmares in those states which utilize numerous agencies, to say nothing of the economic losses incurred because of repetitious processing. California, recognizing this problem, has greatly reduced it through the enactment of the Porter-Cologne Act discussed in greater detail later in this part of the paper.

b. Statutory Treatment

Significantly more important than which agencies are the regulatory authorities are the functions and powers which these agencies are statutorily delegated as well as the means chosen

to affect the state's water resources policies. There are several approaches which have been taken by the states regarding the implementation and regulation of A.G.R. treatment[139] and non-treatment[140] systems. One approach is to regulate both types of A.G.R. systems simultaneously with the same general statutory enactments covering both activities. This approach is taken by the vast majority of states at this time, for the main reason that they believe the regulation of the three functions of ne underground, i.e., water treatment, water storage, and water supply, have not reached a level of pressing urgency. As groundwater regulation becomes of greater importance to a state, it will enact more strict and more specific legislation to handle the situation. Most states do not feel or recognize a need for specifically regulating A.G.R. systems because they are simply not that widely utilized yet. Accordingly, the present general groundwater enactments are felt to adequately cover the present status of A.G.R. utilization. As more A.G.R. installations are utilized, and clearly they will be, the regulation of the practices will take on a greater dimension.

In contrast to this general statutory approach, a few states have enacted specific provisions concerning A.G.R. practices. California[141] has had A.G.R. non-treatment provisions since 1955, while as of 1969 only three states[142] had enacted specific language to deal with A.G.R. non-treatment systems.[143]

c. Policies and Practices

Of more significance than what means the states use to regulate A.G.R. systems is their actual policy and administrative practices when confronted by those seeking to use such systems.

Again, for the sake of clarity and greater ease of description the author resorts to a separate treatment of the legislation dealing with A.G.R. treatment and non-treatment systems.

2. Present A.G.R. Treatment Legislation

As mentioned earlier with respect to A.G.R. treatment legislation, many states rely on general legislative provisions which vest the duties of regulation and protection of groundwaters with one or more controlling authorities. States utilizing this administrative mechanism normally regulate A.G.R. non-treatment practices in the same way under the same blanket provisions.[144] States utilizing this approach could be exemplified by Kentucky's Water Pollution Control Law which vests with the State Water Pollution Control Commission statutory authority to approve or disapprove A.G.R. disposal facilities.[145]

Another approach which is presently being used and which is quite similar the one just described involves utilization of a permit system for those desiring to use A.G.R. facilities.[146] Such permits may be required by legislative statutes or agency regulations. Again, very general blanket provisions are frequently utilized. North Carolina is a typical example of this approach in which a permit is required for the disposal of all wastes into the state's underground.[147]

The final approach utilized in a few states expressly prohibits disposal of wastes in any manner which could enter any of the states water-bearing strata.[148] Strictly construing statutory language of this type would lead one to conclude that neither A.G.R. treatment nor A.G.R. non-treatment systems could

be utilized in states with such provisions. It will be shown later that policy-wise New York has adopted this approach as well with respect to A.G.R. non-treatment systems.

In concluding this subsection of the paper, it is worthy to mention the approach taken by California concerning its implementation and regulation of A.G.R. treatment systems. California has long been acutely aware of the water supply needs of its great and expanding population. It has been, and will continue to be, a front-runner in area of ground and surface water management. Accordingly, California, feeling the pinch of water shortages, has used A.G.R. operations on a large scale for many years,[149] and it enacted the following legislation in 1955 as part of the California Water Code.[150] These sections are discussed also in Part Four of the paper, but are included here to demonstate the broad powers which California felt must necessarily be given its regional water replenishment districts.

> 60220. A district may do any act necessary to replenish the ground water of said district.
>
> 60221. Without being limited to the following enumerations, a district may, among other things, but only for the purposes of replenishing the ground water supplies within the district:
>
> (a) Buy and sell water;
>
> (b) Exchange water;
>
> (c) Distribute water to persons in exchange for ceasing or reducing ground water extractions;
>
> (d) Spread, sink, and inject water into the underground;
>
> (e) Store, transport, recapture, reclaim, purify, treat, or otherwise manage and control water

for the beneficial use of persons or property within the district;

(f) Build the necessary works to achieve ground water replenishment.

60222. A district may take any action necessary to protect or prevent interference with water, the quality thereof, or water rights of persons or property within the district, subject to the limitations contained in Section 60230.

60223. For the purposes of replenishing the ground water supplies within the district, a district may do any act in order to put to beneficial use any water under its control or management.

Such provisions, clearly demonstrate how important A.G.R. treatment utilizations are felt to be in California. This is but further indication that A.G.R. systems are going to be widely accepted and utilized throughout the entire nation within the next decade. Additional credence in this conclusion is demonstrated by the fact that Florida has also adopted essentially this exact language in its Water Resources Act of 1972.[151]

3. Present A.G.R. Non-Treatment Legislation

Turning now to considerations of the present legislation dealing with the non-treatment portion of A.G.R. systems, we also find a relatively sparce amount of specific legislation on point. As mentioned previously, only three states[152] as of 1969 had legislation directly related to A.G.R. non-treatment regulation.[153] The vast majority of states, then and now, utilize general statutory language which vests the regulatory functions and powers with such agencies as the state departments of health or state water pollution commissions, thus using the same controlling authorities to maintain the pollution surveillance as discussed in the last subsection of the paper.

With the preceding commentary as general background to the approaches taken to regulate A.G.R. non-treatment operations, it seems worthwhile to look at the more specific procedures, policies, and practices actually being encountered by those attempting to utilize this means of subterranean disposal by permanent storage. Again, the Cleary and Warner, monograph, Perspective on the Regulation of Underground Injection of Wastewaters[154] can be used to illustrate the contrasting regulatory positions taken by three states as recently as 1969.

a. Ohio

Ohio legislation[155] makes it mandatory for one attempting to use an A.G.R. non-treatment system to obtain a permit prior to the use or installation of any well or borehole "for the production, extraction, or injection of any gas or liquid mineral, excluding potable water to be used as such, but including natural or artificial brines and oil-field waters, sewage and any liquid used in or resulting from any process or industry, manufacture, trade, business, or agriculture."[156]

Cleary and Warner describe the procedure to obtain the permit as follows:

First an application must be filed with the Chief of the Division of Oil and Gas, whose duty it is to determine whether the proposed A.G.R. non-treatment system would present an unreasonable risk of causing wastage or contamination of Ohio's oil and gas resources.

Once it is concluded that no such risk exists, copies of the application are sent to several other state agencies, which include: the Water Pollution Control Board, the Director of Health, the Chief of the Geological Survey, the Chief of the Division of Water, and the Chief of the Division of Mines. Each agency, in turn, makes a determination as to whether or not the proposal is acceptable, and if so, upon what conditions the operation will be allowed. Once these investigations are completed, the applications are returned to the Chief of the Division of Oil and Gas who after studying the applications, issues the disposal permit subject to those conditions which are necessary to promote and protect the health and general welfare of Ohio's inhabitants as well as their valuable natural resources.

It should be finally mentioned, that the Chief of the Division of Oil and Gas also is vested with broad descretionary powers to suspend the permit if it is determined that violations of law, regulations, or conditions of the permit have occurred.

b. West Virginia[157]

West Virginia uses a very similar approach to that of Ohio. West Virginia's Water Code vests extensive regulatory powers over the installation and abandonment of A.G.R. non-treatment systems with the Deputy Director for Oil and Gas of the Department of Mines.

The code specifies geological and other technical information which is required to be furnished before the deputy director can issue the permit to the applicant. The information is also required to be supplied to the Chief of the Division of Water

Resources as well as to each coal mining operation in the area in the event the proposed well is known to be underlain by workable coal deposits.

In addition to these general provisions, Chapter 20, Article 5-A, specifically states that it is unlawful for any person, unless he holds a permit from the Department of Natural Resources, which is in full force and effect, to operate any A.G.R. non-treatment disposal system for the injection under ground of any industrial wastes, or to convert any well into such a disposal well or plug or abandon any such disposal well.

c. New York[158]

New York also uses a permit system. It vests the State Department of Health with the duty of investigation and surveillance of A.G.R. non-treatment operations before and after the permits are issued.

In light of this apparently conventional approach to A.G.R. non-treatment regulation, the Division of Pure Waters of the New York State Department of Health issued a statement of policy, May 29, 1969 which stated (in part):

> The injection of liquid wastes by deep wells is considered a last resort after all other methods have been evaluated; it is a method for gaining long-range storage rather than treatment. The applicant must demonstrate that this method is the optimal approach, and [that it] has the least effect to the total environment.[159]

The effect of this declaration of policy is that although New York uses a permit system which is common in many states, it places a formidable burden of persuasion on any applicant attempting to use A.G.R. non-treatment systems. Essentially,

the New York controlling authority has concluded that the use of A.G.R. non-treatment systems is presently the least satisfactory option for the control of water pollution. Such systems will thus be permitted only as a last resort after all other methods of disposal have been evaluated and found to be less satisfactory.

In light of the conclusions drawn in Part One of this paper, it appears that the New York "last resort policy" approach has significant merit, at least, until complete disclosures of the environmental impact of such systems have been made and found to be non-hazardous.

With this as a background to how some of the states have approached the problem of A.G.R. regulation under their present legislation primarily aimed at controlling and abating groundwater pollution, it is next appropriate to consider the shortcomings which exist with much of the present state legislation.

4. Inadequacies In Present State Regulation

The first problem was alluded to earlier in this portion of the paper.[160] Most states simply have too many agencies charged with authority to regulate, at least, partially various phases encompased by A.G.R. systems and their related activities. This causes confusion for both the individuals being regulated and the agencies doing the regulating. The diversity of agencies with overlapping authority also increases the administrative costs of regulation because each one must investigate the A.G.R. facilities as they relate to the agency's particular area of expertise.

Cleary and Warner[161] suggest that there is another problem which is closely related to the one just described. They believe that there is a failure by many states to have well defined jurisdictional linkages between the related controlling authorities.

James H. Krieger[162] suggests that this problem is complicated by an additional consideration. It is his belief that every river basin is layered with a maze of political subdivisions, each zealously exercising the authority vested in it by the legislature, and that no public agency is likely to relinquish its authority to another agency. This along with the fact that each function of the underground, i.e., water supply, water storage, and water disposal, has its own history and is governed by its own peculiar set of legal principles as described in Part Two of the paper comprise a rather formidable legislative problem in itself.

Other problems arise simply because A.G.R. systems as described in Part One are relatively new and distinct from the present methods of municipal wastewater treatment and water supply, and industrial wastewater treatment and disposal. The complexity and novelty of these potential utilizations of the earth's subsurface as a means of water supply, water storage, and water disposal are still being investigated and are, thus, in rather transitional stages. Accordingly, many states as of yet are unaware of the need to regulate ground and surface waters simultaneously and uniformly. These states are also unaware of the need to regulate A.G.R. treatment and non-treatment practices

as separate and distinct activities if their full environmental benefits are to be obtained.

The final two major problems are common to any regulatory legislation regardless of whether it originates on a local, state, or national level. Simply stated, they are enforcement and financing. The best legislation policies are totally ineffective in the absence of either of these essential administrative requisites.

It is sufficient to say that the old common law means of enforcement are not adequate. The administrative agencies vested with surface and ground water regulatory authority must also be vested with broad enforcement powers if they are to effectively achieve their statutory charge of water resources management. The common law causes of action and remedies are simply too time consuming and too costly to adequately suit the urgency of proper pollution abatement and other water resource management programs.

Water Quality Control: A Modern Approach to State Regulation,[163] states that

> In the past there has been a tendency at both state and federal levels to provide legal authority but not the financial support necessary for effective enforcement, then to blame the administrative agency for its failure to properly utilize the tools it had available, and finally to transfer the enforcement responsibility to a new agency. Increased emphasis, therefore, must be given to adequate financial support for state pollution enforcement agencies.

Legislators must recognize these problems and include in their legislation adequate financial support and enforcement armaments to achieve the environmental objectives which they are attempting to secure.[164]

It could thus be said that one additional problem exists. That is: What is the most effective way to solve or at least minimize each of the present regulatory inadequancies just discussed?

It has been suggested that as the congestion of people and industry increases, some coordination will be achieved:

1) Through increased cooperation between apparently conflicting state regulatory agencies,

2) Through the creation, by state legislatures, of super agencies, and

3) Through an accelerated program of active involvement by the Federal Government.[165]

A discussion of possible solutions is the primary purpose of Part Four and will be undertaken there; however, before moving on to the final portion of the paper, brief mention should be made of the present status of federal legislation related to A.G.R. practices.

B. Federal Legislation

At the present time, there is no specific federal legislation regarding A.G.R. treatment or non-treatment practices, with the one exception of having to obtain the approval of the Atomic Energy Commission for the disposal of any radioactive wastes. The authorization and regulation of A.G.R. systems are the responsibility of the individual states.[166] It is this author's opinion that this is as it should be, for it is clear that each state has a substantially greater interest in its groundwater resources at the present time. In time, however, it will become necessary for the federal government to coordinate the regulatory activities

between the states. Therefore, Congress must remain cognizant of the potential utility of A.G.R. systems in order to be prepared to enact the kind of legislation necessary when it becomes appropriate for Congressional action.

The Federal Water Pollution Control Act of 1964,[167] states in its declaration of policy that Congress intends to "recognize, preserve, and protect the primary responsibilities and rights of the States in preventing and controlling water pollution." Although the Act is primarily concerned with the pollution control of the nation's interstate waterways and their tributaries, it also comprehends the improvement the "sanitary condition of surface and underground waters."[168] To this end, the Act authorizes the Department of the Interior to "conduct, encourage, cooperate with, and render assistance to other appropriate public (whether Federal, State, interstate, or local) authorities, agencies, and institutions, private agencies and institutions, and individuals in the conduct of, and promote the coordination of research, investigations, experiments, demonstrations and studies relating to the causes, control, and prevention of water pollution."[169] In carrying out the provisions of this charge, the research, studies, and experiments are to include, among other things:

> Practical means of treating municipal sewage and other waterborne wastes to remove the maximum possible amounts of physical, chemical, and biological pollutants in order to restore and maintain the maximum amount of the Nation's waters at a quality suitable for repeated reuse.[170]

Further, the Act authorizes the Department of Interior to make grants to any State, municipality, or intermunicipal or interstate agency for the following purposes, among others, of:

> Assisting in the development of any project which will demonstrate advanced waste treatment and water purification methods * * * or new or improved methods of joint treatment systems for municipal and industrial wastes, and for the purpose of reports, plans, and specifications in connection therewith.[171]

These provisions of the Federal Water Pollution Control Act, although not directly aimed at A.G.R. implementation and regulation, do indicate that Congress is significantly concerned with many of those water quality conditions that could be ameliorated by the use of A.G.R. systems. The federal government has made substantial allocations to research projects which have dealt with many of the subjects associated with A.G.R. practices.[172] Accordingly, it can not be said that the federal government is not actively involved with groundwater pollution problems.

Congress is considering a bill[173] which calls for the complete elimination of all industrial and muncipal pollutant discharges to lakes and streams by 1985.[172] This emphasizes that Congress is cognizant of the importance of groundwater regulation, for if the bill passes by the middle of the next decade, municipal and industrial waste dischargers alike must halt their use of our nation's rivers, streams, and lakes as means of securring waste disposal. In effect, the waste discharges would have to be treated to a point such that A.G.R. systems can safely treat and dispose of these effluents. Only through A.G.R. implementation and regulation can this enactment achieve its socially desirable goal of environmental water quality enhancement. Appropriate legislation will be necessary in the very near future to ensure its success.

Before turning to Part Four and its suggested legislation regarding A.G.R. systems, it is worthwhile to conclude Part Three by briefly reviewing some trends in groundwater legislation and regulation.

C. Trends in Current Legislation

Since publication of the Model Water Use Act[174] in 1958 and the Suggested State Water Pollution Control Act[175] in 1965, much legal research has been conducted in the area of proposing legislation to control, maintain, and improve the quality of our nation's water resources. Two such examples of this work were:

1) A study project which made a comprehensive review of the water quality control laws of California. Its purpose was to identify and analyze legal, engineering, and administrative problems of California's then existing legislation and to recommend legislative and administrative changes to the California Legislature. The California Water Resources Control Board undertook the study in May of 1968 at the request of Charley V. Porter, a California legislator active in the water resources area. The board presented its Final Report: Recommended Changes in Water Quality Control[176] to the California Legislature in March of 1969. This report in turn culminated in the enactment of California's Porter-Cologne Water Quality Control Act of 1970.[177]

2) A similar result was reached by a study undertaken by Frank E. Maloney and Richard C. Ausness who prepared the article, cited earlier, entitled Water Quality Control: A Modern Approach to State Regulation.[178] This research project was supported by

the Office of Water Resources Research, United States Department of the Interior. Essentially, the study formed the basic underpinnings of much of Florida's Water Resources Act of 1972.[179]

Much could be said about the advantages of both these comparable enactments, but perhaps a recent comment by P. H. McGauhey, cited earlier, most profoundly summarizes their potential utility. McGauhey stated:

> History may well record that 1969 was the Year of the Environment, for it was in that year that the concern of citizens for the world about them reached a critical mass that had profound effects on what for many years had been called water pollution control. Most notable of these effects in California was the creation of a political climate favorable for passage of the Porter-Cologne Act. This act broke through the institutional roadblocks that had long made it impossible for the best efforts of dedicated pollution control officials and concerned citizens to prevent a continued deterioration of water quality.
>
> Although it is too early for all problems of water pollution in California to have been resolved by the actions of the new Water Resources Control Board, communities which for more than 20 years had gained little in their waste water management efforts suddenly found the official and public resources to move rapidly toward needed improvements. Thus, the greatest contribution of 1969 to the cause of clean water was the demonstration that the link between the environmental goals of society and the capabilities of technology could be established by social and political action. With such a link established it is possible, in at least one of our 50 states, to engage in planning for clean water in terms of ecology and social environment.[180]

Although a brief discussion of the acts could not possibly do justice to either one, some mention of the general nature of the enactments must be made. Both the California and Florida enactments utilize a two-tier administrative system comprised of a state water resources control board and a number of regional water management districts. Essentially, their arrangement

utilizes on the first tier a state-wide coordinating authority which oversees the activities of the second tier regional water management districts. The administrative agencies on both tiers are delegated broad powers of implementation, regulation, and enforcement of activities associated with the maintenance, development, and improvement of their respective state's natural surface and ground water resources.

It can be concluded that each act significantly overcomes and reduces many of the major inadequacies related to present A.G.R. legislation. They both provide an improved means of financing pollution abatement facilities and research projects. They both contain a substantially increased enforcement arsonal to police all activities associated with their respective state's surface and ground water resources. They are sufficiently liberal to take account of the technological advances in A.G.R. processes as they become operative. Although the acts do not restrict the powers vested in ancillary regulatory agencies, they do at least set a priority as to which agency is vested with the primary water quality (and quantity) regulatory authority within the state. This established priority also effectively reduces many of the weaknesses which most states have due to their lack of well defined jurisdictional linkages between the related controlling authorities.

These studies are recommended to those individuals who are undertaking a project for revising state legislation in the area of water resources management. It is suggested that the legislative treatment prescribed by California's Porter-Cologne Water

Quality Control Act of 1970 and Florida's Water Resources Act of 1972 offer the kind of approach to water resources management which should provide an effective means of protecting, conserving, and developing the quality and quantity of ground and surface water resources, while optimizing their beneficial uses. It is this type of fully coordinated approach which integrates quality control into the management and regulation of all of a state's waters which appears to be the trend taking form in current legislation.

V. Part Four: Proposed Legislation

A. Introduction

The A.G.R. legislative proposals contained herein are essentially intended to be used within a state's present regulatory structure. They should be looked upon as an adjunct to be enacted by those states which find that more regulatory control is necessary to properly conserve and develop their surface and ground water resources. An attempt has been made to keep the legislative proposals of Part Four related as closely as possible to those findings and conclusions contained in Parts One, Two, and Three.

B. Suggested State A.G.R. Legislation

Section 1. Declaration of Policy

(1) The Legislature recognizes, finds, and declares that the subterranean portions of the earth have historically served three vital environmental functions

as a source of water supply, water storage, and water disposal naturally without need of man's interaction; that today, however, it becomes increasingly obvious that with increases in the population, productivity, and prosperity of this state that regulatory controls must be established to maintain the optimum utility of the earth's subterranean hydrologic processes.

(2) The Legislature further finds and declares that since the people of the state have a primary interest in the conservation, protection, utilization, and development of the water resources of the state, that the health, safety, and welfare of the people of the state requires that there be a state-wide program for the control of the quality and quantity of all the waters of the state; that the state must be prepared to exercise its full power and jurisdiction to protect through regulation the quality of the state's ground waters just as cautiously as it protects its surface water resources.

(3) To achieve this objective, the Legislature further recognizes, finds and declares that significant advancements have recently been made in the area of wastewater treatment and disposal facilities which artificially recharge subterranean reaches of the earth; that widespread adoption and utilization of

facilities which utilize these advancements could offer many potential environmental and sociological benefits by providing a means of wastewater treatment for domestic and certain industrial wastes economically and technologically superior to the in-plant processes currently being used, a means to improve and increase the state's water supply, while providing a readily available large reservoir for storing potable waters without evaporation losses, and providing protection from pollution and radioactive fallout, and which can be developed in stages corresponding to an area's population increase and industrial growth, if such treatment and disposal systems are developed within reasonable technological constraints and regulated within the limits established hereinafter.

(4) It is the intent of the Legislature that the state agency charged with the primary responsibility for the coordination and control of the state's water resources shall treat surface and ground waters inseparably and regulate and manage the quality and quantity of both uniformly and simultaneously, within the agency's present framework and administrative hierarchy.

COMMENTARY. Subsection (1) emphasizes several of the findings and conclusions contained in Parts One, Two and Three of the paper. For example, it recognizes that while the three environmental functions of water supply, storage, and disposal

performed by the earth's soil mantle could once be considered separate and distinct processes, that with our present population growth and industrial expansion, such thinking is simply not possible or plansible, today. Subsection (1) declares that each such function must now be carefully monitored and regulated to maximize the soil mantle's continued utility in providing a means of water supply, storage, and disposal. Subsection (3) emphasizes that significant technological progress has occurred in the area of utilizing surface and subterranean portions of the earth's soil mantle as a means of obtaining advanced wastewater treatment of domestic and certain industrial effluents, increased ground water supplies, and potentially much less costly and more convenient disposal of refractory chemical pollutants. Although all of these potential environmental and sociological benefits can not yet be fully achieved, many of them can be. Subsection (3) declares that the time to strive for their full attainment is now. The legislation contained hereinafter includes the technological constraints which must be maintained as well as the implementing authority to achieve those advantageous utilizations which should be endorsed. Subsections (2) and (4) emphasize the fact that the only way to efficiently regulate the systematic conservation, protection, utilization, and development of the water resources of the state is to manage both surface and ground waters through one administrative agency, uniformly and simultaneously.

Subsection (2) was derived from a California statute.[181] Subsections (1), (3), and (4) are original.

Section 2. Definitions

(1) "Artificial Groundwater Recharge" (A.G.R.), includes any man-made process or human activity which introduces any liquid into the underground.

(2) "Artificial Groundwater Recharge Facilities" include any facilities which are used to introduce any liquid into the underground. Artificial groundwater recharge systems can be categorized into two distinct classifications based on whether or not the surface of the earth's soil mantle is used as a treatment mechanism. The classifications are designated:

(a) . Artificial Groundwater Treatment Facilities, and

(b) Artificial Groundwater Non-Treatment Facilities.

(3) "Artificial Groundwater Treatment Facilities" are those disposal systems which utilize the natural treatment processes of the surface of the earth's soil mantle to obtain advanced wastewater treatment for domestic and certain industrial effluents before they are introduced into the underground.

(4) "Artificial Groundwater Recharge Non-treatment Facilities" are those disposal systems which do not utilize the natural treatment processes of the earth's soil mantle, and thus provide essentially no wastewater treatment for the effluents before they are

introduced into the underground. Basically, artificial groundwater recharge non-treatment systems provide no treatment, only disposal by permanent subterranean storage.

(5) "Waters" mean any and all water, public or private, on or beneath the surface of the ground, which are contained within, flow through, or border upon the state or any portion thereof except those bodies of waters confined to and retained within the limits of private property in single ownership which do not combine or affect a junction with natural surface or underground waters.

COMMENTARY. Subsections (1), (2), (3), and (4) establish a sufficiently broad definitional framework within which every type of treatment and/or disposal facility which affects or could affect surface or ground water resources can be classified and thereafter properly regulated within its "treatment-non-treatment" dichotomy. This is so whether the facility is privately or publicly owned and operated, regardless of the name by which it is commonly known, such as wastewater reclamation unit, subsurface disposal plant, deep-well injection system, spray irrigation system, artificial groundwater recharge facility, etc. The significance of the treatment--non-treatment dichotomy is readily apparent. The legislative proposals contained hereinafter accord each type system separate and distinct statutory treatment. Subsection (5) is included within the definition's

section to provide a state desiring to implement total ground and surface water resource regulation with the broadest categorical definition of "waters" which this author could find. No clearer statement of the legislative intent to regulate the surface and ground waters of the state can be made than the enactment of such a broad and unequivocal definition.

Subsection (5) was derived from a Tennessee statute.[182] Subsection (1), (2), (3), and (4) are original.

Section 3. Artificial Groundwater Recharge Treatment Facilities

(1) The state water control agency shall have regulatory authority over the construction, operation, and abandonment of artificial groundwater recharge treatment facilities through the timely dispatch of permits which shall require approval for each phase of a facility's installation, operation, and abandonment; furthermore, the agency shall recommend, advocate, and otherwise foster the private and public utilization of the less costly and more effective artificial groundwater recharge treatment systems in those areas of the state in which the requisite design parameters can be met to the final elimination of the conventional in-plant type sewage treatment facilities within the state. When expansion of present in-plant facilities is requested, the agency shall similarly recommend and advocate the conversion of such plants into artificial

groundwater treatment facilities where the design parameters can be met.

(2) The agency is delegated the power to establish by regulation all necessary and proper administrative and technological regulatory guidelines to accomplish the directive of paragraph (1) above. The design parameters to be established by the agency for artificial groundwater treatment facilities should include, among other things, considerations of location, geology, topography, hydrology, soil profiles, areas for future expansion, adjacent land use, construction details, ground and surface water quality surveys, location of groundwater table, type and quantity of effluent treated (whether domestic or industrial), number of treatment lagoons, their retention time, type sprinkler or spreading systems, surface loading rates, surface clogging rates, degree of treatment expected and attained, monitering equipment and procedures, emergency by-pass and back-up treatment facilities, run-off, fencing, warning signs, as well as a study of the over-all environmental impact of the facility.[183]

(3) The agency may do any act necessary to replenish the ground water of any area of the state.

(4) The agency may, among other things, but only for the purposes of protecting the quality or replenishing

the quantity of ground water supplies within the state:

(a) Buy and sell water;

(b) Exchange water;

(c) Distribute water to persons in exchange for ceasing or reducing ground water extractions;

(d) Spread, sink, and inject water into the underground;

(e) Store, transport, recapture, reclaim,* purify, treat, or otherwise manage and control water for the beneficial use of persons or property within the state;

(f) Build the necessary works to achieve ground water replenishment.

(5) For the purposes of protecting the quality or replenishing the quantity of ground water supplies within the state, the agency may do any act in order to put to beneficial use any water under its control or management.

COMMENTARY. Essentially, section 3 provides the state water control agency with broad powers for implementing and regulating the various phases associated with A.G.R. treatment facilities.

*See appendix for California provisions on this one significant aspect of A.G.R. regulation, Cal. Stat. §§ 13500 et seq. (1970).

In effect, section 3 should allow the state to realize all the potential environmental and sociological advantages described in the Declaration of Policy of section 1 which were more fully discussed in Part One, while being confined by only those reasonable constraints which require safe and proper design, construction, and operation. As demonstrated by the appendix citation, it can be seen that section 3 also provides an essential stepping-off point for more extensive and beneficial legislative management of all subjects associated with the conservation and development of surface, and particularly the more remote ground water resources. Section 3 should serve any state desiring more control over its groundwater resources very well. It contains not only prohibitory provisions but also useful implementing language which allows the state to take affirmative action to maximize the utility of its groundwater resources.

Subsections (3) and (4) were derived from California statutes.[184] Subsections (1), (2), and (5) are original.

Section 4. Artificial Groundwater Recharge Non-treatment Facilities

(1) The state water control agency shall have regulatory authority over the construction, operation, and abandonment of artificial groundwater recharge non-treatment facilities through the timely dispatch of permits which shall require approval for each phase of a facility's installation, operation and abandonment; furthermore the agency shall hereafter approve no such permits for

the injection of any gas or liquid mineral, excluding potable water to be used as such, but including natural or artificial brines and oil-field waters, sewage and any liquid used in or resulting from any process or industry, manufacture, trade, business, or agriculture, on other than isolated test or pilot research plant bases, until full environmental impact disclosures have been made and shown to be essentially non-hazardous to the water and other valuable natural resources of the state.

(2) The agency is delegated the power to establish by regulation all necessary and proper administrative and technological guidelines to accomplish the directive of paragraph (1) above. The design parameters to be established by the agency for artificial groundwater recharge non-treatment facilities should include, among other things, considerations of location, geology, topography, hydrology, soil profiles, areas for future expansion, adjacent land use, construction details, ground and surface water quality surveys, location of groundwater table, soil strata-chemical effluent compatability, types and quantities of effluents being injected, injection rates and pressures (maintained below levels at which hydraulic fracturing of formation parting occurs), monitering equipment and procedures, emergency by-pass and back-up treatment

facilities, fencing, warning signs, as well as a study on the over-all environmental impact of the facility.[185]

COMMENTARY. Section 4, unlike section 3, does not strive to affect immediate implementation of A.G.R. non-treatment facilities on other than special isolated test or pilot research plant bases. Although A.G.R. non-treatment systems may (and hopefully will) be shown in the future to represent a safe, convenient, and economical means of disposal for refractory industrial wastes, section 4 enacts the conclusion, drawn in Part One, that the utilization of such systems should not be permitted hereafter until complete disclosures of their environmental impact have been made and concluded to be non-hazardous beyond reasonable doubt. Research, however, should be continued on A.G.R. non-treatment systems. Accordingly, section 4 allows utilizations of such systems where used primarily as research facilities. Section 6, infra, actually charges the water control agency with the duty and responsibility of conducting and aiding research investigations, (whether public or private) for the refinement of both A.G.R. treatment and non-treatment facilities. Section 4, then, is principally a precautionary provision to restrain the possibly imprudent proliferation of A.G.R. non-treatment systems until they are shown to be environmentally safe.

Section 4 is essentially original.

Section 5. Reserved Continuing Jurisdiction

The state water control agency retains continuing jurisdictional authority over all artificial groundwater recharge treatment and non-treatment facilities

with the power to suspend or revoke temporarily or permanently the respective permits at any time violations of the conditions of the installation, operation or abandonment permits are disclosed which cause reasonable suspicion that pollution or other environmental injury has been or may be incurred by private or public property from the facility's malfunctioning or improper management. This section shall not be construed as abridging any other rights, powers, or remedies of either the water control agency o its regulated applicants.

COMMENTARY. The suggested legislative proposals contained herein are to be used as an adjunct to a state's present groundwater regulatory legislation. Section 5 is included merely to emphasize that the state water control agency must continue its regulatory duties from the time of an A.G.R. facility's inception to its final abandonment. The final sentence of section 5 emphasizes that the agency's suspension and revocation powers do not abridge any other enforcement powers which it might have, but neither does it abridge the substantive due process rights of notice and a hearing which are granted the regulated applicants either statutorily or judicially.

Section 5 is original.

Section 6. Research and Development

The agency, either independently or in cooperation with any person or any county, state, federal, or

other agency, to the extent funds are allocated therefore, shall conduct surveys and investigations relating to the refinement of the design, construction, operation, maintenance and abandonment of both artificial groundwater recharge treatment and non-treatment systems, as well as relating to any other subject matter which could refine or maximize the utility of the three functions of the underground as a source of water supply, water storage, and water disposal.

COMMENTARY. Section 6 is essentially self-explanatory. A.G.R. systems are a relatively new approach to obtaining waste treatment and disposal, while affecting artificial groundwater recharge and storage, which in turn, increases our ground water supplies. The regulation of A.G.R. practices embraces the regulation of the closed system comprised of the subterranean hydrologic cycle. Continued research of all the related activities and processes is necessary in order for the optimum balance and maximum utility of the three underground water functions to be achieved.

Section 6 is original.

C. Final Conclusion

It is the author's hope that this study with its proposed legislation on A.G.R. practices serves as a useful tool in the nation's drive for enhanced surface and ground water quality. If it draws no other conclusion, let it at least stand for the

principle that good legislative treatment of A.G.R. practices and groundwaters generally is absolutely essential to the continued prosperity of the nation and well-being of its citizens.

APPENDIX

Chapter 7. Water Reclamation

Article 1. Short Title

13500. This chapter shall be known as and may be cited as the Water Reclamation Law.

Article 2. Declaration of Policy

13510. It is hereby declared that the people of the state have a primary interest in the development of facilities to reclaim water containing waste to supplement existing surface and underground water supplies and to assist in meeting the future water requirements of the state.

13511. The Legislature finds and declares that a substantial portion of the future water requirements of this state may be economically met by beneficial use of reclaimed water.

The Legislature further finds and declares that the utilization of reclaimed water by local communities for domestic, agricultural, industrial, recreational, and fish and wildlife purposes will contribute to the peace, health, safety and welfare of the people of the state. Use of reclaimed water constitutes the development of "new basic water supplies" as that term is used in Chapter 5 (commencing with Section 12880) of Part 6 of Division 6.

13512. It is the intention of the Legislature that the state undertake all possible steps to encourage development of water reclamation facilities so that reclaimed water may be made available to help meet the growing water requirements of the state.

Article 3. State Assistance

13515. In order to implement the policy declarations of this chapter, the state board is authorized to provide loans for the development of water reclamation facilities, or for studies and investigations in connection with water reclamation, pursuant to the provisions of Chapter 6 (commencing with Section 13400) of this division.

Article 4. Regulation of Reclamation

13520. As used in this article "reclamation criteria" are the levels of constituents of reclaimed water, and means for assurance of reliability under the design concept which will

result in reclaimed water safe from the standpoint of public health, for the uses to be made.

13521. The State Department of Public Health shall establish state-wide reclamation criteria for each varying type of use of reclaimed water where such use involves the protection of public health.

13522. Whenever the State Department of Public Health or any local health officer finds that a contamination exists as a result of use of reclaimed water, the department or local health officer shall order the contamination abated in accordance with the procedure provided for in Chapter 6 (commencing with Section 5400) of Part 3, Division 5 of the Health and Safety Code.

13522.5. (a) Any person reclaiming or proposing to reclaim water or using or proposing to use reclaimed water within any region for any purpose for which reclamation criteria have been established, shall file with the regional board of that region a report containing such information as may be required by the board.

(b) Every person reclaiming water or using reclaimed water shall file with the regional board of that region a report of any material change or proposed change in the character of the reclaimed water or its use.

(c) Each report under this section shall be sworn to or submitted under penalty of perjury.

(d) The provisions of this section shall not be construed so as to require any such report in the case of any producing, manufacturing, or processing operation involving the reclamation of water solely for use in such producing, manufacturing or processing operation.

(Added by Stats. 1970, Ch. 918.)

13522.6. Any person failing to furnish a report under Section 13522.5 when so requested by a regional board is guilty of a misdemeanor.

(Added by Stats. 1970, Ch. 918.)

13522.7. The Attorney General, at the request of the regional board, shall petition the superior court for the issuance of a temporary restraining order, temporary injunction or permanent injunction, or combination thereof, as may be appropriate, requiring any person not complying with Section 13522.5 to comply forthwith.

(Added by Stats. 1970, Ch. 918.)

13523. Each regional board, after consulting with and receiving the recommendations of the State Department of Public Health and after any necessary hearing, shall, if it determines such action to be necessary to protect the public health, safety, or welfare, prescribe water reclamation requirements for water

which is used or proposed to be used as reclaimed water. Requirements may be placed upon the person reclaiming water, the user, or both. Such requirements shall include, or be in conformance with, the statewide reclamation criteria established pursuant to this article. The regional board may require the submission of a preconstruction report for the purpose of determining compliance with the reclamation criteria.

(Amended by Stats. 1970, Ch. 918.)

13524. No person shall reclaim water or use reclaimed water for any purpose for which reclamation criteria have been established until water reclamation requirements have been established pursuant to this article or a regional board determines that no requirements are necessary.

(Former 13525; amended and renumbered 13524 by Stats. 1970, Ch. 918.)

13525. Upon the refusal or failure of any person or persons reclaiming water or using reclaimed water to comply with the provisions of this article, the Attorney General, at the request of the regional board, shall petition the superior court for the issuance of a temporary restraining order, preliminary injunction, or permanent injunction, or combination thereof, as may be appropriate, prohibiting forthwith any person or persons from violating or threatening to violate the provisions of this article.

(Former 13524; amended and renumbered 13525 by Stats. 1970, Ch. 918.)

13525.5 Any person reclaiming water or using reclaimed water in violation of Section 13524, after such violation has been called to his attention in writing by the regional board, is guilty of a misdemeanor. Each day of such reclaiming or use shall constitute a separate offense

(Added by Stats. 1970, Ch. 918.)

13526. Any person who, after such action has been called to his attention in writing by the regional board, uses reclaimed water for any purpose for which reclamation criteria have been established prior to the establishment of water reclamation requirements, is guilty of a misdemeanor.

13527. In administering any statewide program of financial assistance for water pollution or water quality control which may be delegated to it pursuant to Chapter 6 (commencing with Section 13400) of this division, the state board shall give added consideration to water quality control facilities providing optimum water reclamation and use of reclaimed water.

Nothing in this chapter prevents the appropriate regional board from establishing waste discharge requirements if a discharge is involved.

13528. No provision of this chapter shall be construed as affecting the existing powers of the State Department of Public Health.

Article 5. Surveys and Investigations

13530. The department, either independently or in cooperation with any person or any county, state, federal, or other agency, or on request of the state board, to the extent funds are allocated therefor, shall conduct surveys and investigations relating to the reclamation of water from waste pursuant to Section 230.

Article 6. Waste Well Regulation

13540. No person shall construct, maintain or use any waste well extending to or into a subterranean water-bearing stratum that is used or intended to be used as, or is suitable for, a source of water supply for domestic purposes. Notwithstanding the foregoing, when a regional board finds that water quality considerations do not preclude controlled recharge of such stratum by direct injection, and when the State Board of Public Health, following a public hearing, finds the proposed recharge will not impair the quality of water in the receiving aquifer as a source of water supply for domestic purposes, reclaimed water may be injected by a well into such stratum. The State Board of Public Health may make and enforce such regulations pertaining thereto as it deems proper. Nothing in this section shall be construed to affect the authority of the state board or regional boards to prescribe and enforce requirements for such discharge.

13541. As used in this article, "waste well" includes any hole dug or drilled into the ground, used or intended to be used for the disposal of waste.

FOOTNOTES

1. See generally Meinzer, Outline of Ground-Water Hydrology (U. S. Geol. Survey Water Supply Paper 494, 1923).

2. See generally Warner, Deep-Wells for Industrial Waste Injection in the United-States - Summary of Data (U. S. Dep't. of Interior, FWPCA, Bull. WP-20-10, 1967).

3. See generally McGauhey & Krone, Soil Mantle as a Wastewater Treatment System - Final Report (U. S. Dep't. of Interior, FWPCA, SERL Report No. 67-11, 1967) [hereinafter cited as McGauhey & Krone].

4. See generally Cleary & Warner, Perspective on the Regulation of Underground Injection of Wastewaters (Ohio River Valley Water Sanitation Comm., 1969).

5. Skodje, Use of Gravity Shafts for Recharge, 61 Am. Water Works Ass'n. J. 246 (1969).

6. McGauhey & Krone, supra note 3, at 70.

7. Id. at 168.

8. Id. at 146.

9. Id.

10. See generally, Recommended Standards for Sewage Works (Great Lakes - Upper Miss. River Bd. of Sanitary Eng'rs., 1971) [hereinafter cited as Recommended Sewage Standards].

11. Id. at addendum No. 2 p. 1.

12. Amramy, Waste Treatment for Groundwater Recharge, 36 Water Poll. Control Fed. J. 296 (1964).

13. Proceedings of Sixth Biennial Conference on Ground Water Recharge, Development and Management (Univ. of Calif. Berkeley, at 111, 1967) [hereinafter cited as Sixth Biennial].

14. Baffa & Bartilucci, Wastewater Reclamation by Groundwater Recharge on Long Island, 39 Water Poll. Control Fed. J. 431 (1967).

15. Parkhurst, Wastewater Reuse - A Supplemental Supply, 96 J. Sanitary Eng'r. Div. of ASCE 653 (1970).

16. Storm, Land disposal: one answer, 8-10 Water & Wastes Engineering 46 (1971).

17. Hearings on Phosphate Reduction Before the Subcommittee on Conservation and Natural Resources, 91st. Cong., 2d Sess. at 216 (December 15 & 16, 1969) [hereinafter cited as 1969 Hearings]; See also House Report 91-1004 (April 14, 1970).

18. Id.

19. P. H. McGauhey, Engineering Management of Water Quality (1968).

20. 1969 Hearings, supra note 17, at 222.

21. Amramy, Waste Treatment for Groundwater Recharge, 36 Water Poll. Control Fed. J. 296 (1964).

22. 1969 Hearings, supra note 17, at 215.

23. Id. at 216.

24. Bouwer, Returning Wastes to the Land, A New Role for Agriculture, 23 Soil and Water Conservation J. 164 (1968).

25. Much of the commentary of this subsection is derived from a monograph written by Cleary & Warner, Prespective on the Regulation of Underground Injection of Wastewaters (Ohio River Valley Water Sanitation Comm., 1969). More specifically this portion of the paper consists of a synopsis of an article by Cleary & Warner, Some Considerations in Underground Wastewater Disposal, 62 Am. Water Works Ass'n. J. 489 (1970) written from the monograph [hereinafter cited as Cleary & Warner]. The monograph outlines the current status of subsurface injection disposal of industrial wastes. It raises questions regarding the public policy issues as well as other legal and legislative aspects involved. Finally, it suggests criteria, regulations, and procedures to satisfy the administrative needs to police the presently questionable injection-well practices. See also Walker & Stewart, Deep-Well Disposal of Wastes, 94 J. Sanitary Eng'r. Div. of ASCE 948 (1968).

26. Cleary & Warner, supra note 25, at 490.

27. Id.

28. Id.

29. Id.

30. Id.

31. Id.

32. McGauhey & Krone, supra note 3, at 146.

33. Cleary & Warner, supra note 25, at 490.

34. Note, this suggests use of the Interstate Commerce Clause of the Federal Constitution as providing a means of imposing national regulation of groundwaters.

35. Cleary & Warner, supra note 25, at 489.

36. 1969 Hearings, supra note 17, at 213.

37. Sixth Biennial, supra note 13, at 8.

38. Florida Water Resources Study Comm'n., Florida's Water Resources, Report to the Governor of Florida and the 1957 Legislature 33 (1956).

39. Recommended Sewage Standards, supra note 10, at addendum No. 2 p. 1.

40. McGauhey & Krone, supra note 3, at 2.

41. 1969 Hearings, supra note 17, at 214.

42. P. H. McGauhey, Engineering Management of Water Quality (1968).

43. 1969 Hearings, supra note 17, at 211.

44. Report of the Interim Fact-Finding Committee on Water Pollution Assembly of the State of California 138 (1949).

45. McGauhey & Krone, supra note 3, at 92.

46. 1969 Hearings, supra note 17, at 210.

47. Id. at 216.

48. Id. at 215.

49. Id. at 220.

50. Id. at 215.

51. Id. at 211.

52. Id.

53. Id. at 214.

54. Id. at 213.

55. Id. at 217.

56. Cleary & Warner, supra note 25, at 490.

57. Id.

58. Id. at 491.

59. Id. at 497.

60. See generally Commoner, Environmental Pollution, World Almanac 463 (1971).

61. Sixth Biennial, supra note 13, at 38.

62. Under the dual sovereignty theory, both the state and federal governments each as sovereigns may exercise reasonable "control" to protect the health, safety, morals, and general welfare of their respective citizens.

63. Sixth Biennial, supra note 13, at 174.

64. Cleary & Warner, supra note 25, at 496.

65. See generally Maloney & Plager, Florida's Ground Water: Legal Problems in Managing a Precious Resource. 21 U. Miami L. Rev. 721 (1967) for an interesting and detailed description of the legal problems associated with consumptive utilizations of groundwater [hereinafter cited as Maloney & Plager].

66. See generally Annot., 55 A.L.R. 1450 (1928); 109 A.L.R. 412 (1937).

67. Bountiful City v. DeLuca, 77 Utah 107, 292 P. 194, 72 A.L.R. 657 (1930).

68. Durham v. Eno Cottom Mills, 141 N.C. 615, 54 S.W. 453, 7 L.R.A. (NS) 321 (1906).

69. Bountiful City v. DeLuca, 77 Utah 107, 292 P. 194, 72 A.L.R. 657 (1930); see Annot., 11 L.R.A. (NS) 1164.

70. Bountiful City v. DeLuca, 77 Utah 107, 292 P. 194, 72 A.L.R. 657 (1930).

71. 100 N.H. 294, 124 A. 2d 189 (1956).

72. 48 N.Y.S. 2d 212 (Ct Cl, 1944).

73. 244 S.C. 228, 136 S.E. 2d 291 (1964).

74. See generally Ellison v. Rayonier, Inc. 156 F. Supp. 214 (D.C. Wash., 1957).

75. Maloney & Plager, supra note 65, at 751.

76. Id. at 753.

77. Id.

78. See generally Annot., 55 A.L.R. 1385, 1386-88 (1928); 109 A.L.R. 395, 397 (1937).

79. See generally Annot., 29 A.L.R. 2d 1354 (1953).

80. See generally Annot., 38 A.L.R. 2d 1265, 1268 (1954).

81. See generally 56 Am. Jur., Waters Sec. 113 (1947).

82. See generally 55 A.L.R. 1385, 1435 (1928); 109 A.L.R. 395, 406 (1937).

83. Gilmore v. Royal Salt Co., 84 Kan. 729, 115 P. 541 (1911).

84. Ulmen v. Mt. Angel, 57 Or. 547, 112 P. 529 (1911).

85. Beatrice Gas Co. v. Thomas, 41 Neb. 662, 59 N.W. 925 (1894).

86. See generally 56 Am. Jr., Waters Sec. 126 (1947).

87. See generally 56 Am. Jur., Waters Sec. 362 (1947).

88. 24 Idaho 36, 133 P. 916 (1913).

89. For a discussion see Maloney, The Balance of Convenience Doctrine, 5 S.C.L.Q. 159 (1952); Harrisonville v. W. S. Dickey Clay Mfg. Co., 289 U.S. 334, 337-38 (1933), Mr. Justice Brandeis, "For an injunction is not a remedy which issues as of course. Where substantial redress can be afforded by the payment of money and issuance of an injunction would subject the defendant to grossly disproportionate hardship, equitable relief may be denied although the nuisance is indisputable."

90. City of Harrisonville v. W. S. Dickey Clay Mfg. Co., 61 F. 2d 210 (8th Cir. 1932).

91. City of Clanton v. Johnson, 245 Ala. 270, 17 So. 2d 669 (1944) which involved damages for pollution injury from city sewage flowing into plaintiff's creek.

92. See generally W. Prosser, Law of Torts 145 (1971) [hereinafter cited as Prosser].

93. 109 F. Supp. 924 (D.C. Alaska, 1953).

94. 201 Pa. Super 614, 193 A. 2d 670 (1963).

95. Restatement (First) of Torts Subsection 822-840 (1939).

96. Restatement (First) of Torts, Explanatory Notes Sec. 849, comment b, illustration 5 at 338 (1939).

97. See generally Prosser, supra note 92, at 591.

98. See generally Sharp, Liability of Landowner for Pollution of Percolating Waters, 39 Marquette L. Rev. 119 (1955).

99. 371 Okla. 371 P. 2d 81 (Okla. 1961).

100. 113 Pa. 126, 6 A. 453 (1886).

101. L.R. 1 Ex. 265 (1866), affirmed L.R. 3 H.L. 330 (1868).

102. See generally Prosser, supra note 92, at 509.

103. 81 Ill. App. 424 (1899).

104. 160 Kan. 697, 165 P 2d 601 (1946).

105. See Prosser, supra note 92, at 512.

106. 23 Cal. 2d 68, 142 P. 2d 289 (1943).

107. Prosser, supra note 92, at 509.

108. Id. at 63.

109. Kelley, Trespass in Secondary Recovery, 17 Southwestern L. J. 591 (1963).

110. See generally Smith, Statutory Treatment of Industrial Steam Pollution, 24 George Washington L. Rev. 301 (1956).

111. See generally Annot., 32 A.L.R. 3d 215 (1970).

112. Durham v. Eno Cotton Mills, 141 N.C. 615, 54 S.E. 453, 7 L.R.A. (NS) 321 (1906).

113. 128 Tex. 155, 96 S.W. 2d 221 (1936).

114. See generally Woolley, Oil and Gas Pollution of Subsurface Waters - Absolute Liability, 11 Southwestern L.J. 252 (1963).

115. See generally Prosser, supra note 92, at 281.

116. See generally Annot., 55 A.L.R. 1385, 1441 (1928).

117. See generally 56 Am. Jur., Waters Sec. 414 (1947).

118. Id.

119. 201 Pa. Super 614, 193 A. 2d 670 (1963).

120. 259 S.W. 2d 466, 38 A.L.R. 2d 1261 (1953).

121. Middlekampt v. Bessemer Irrigation Ditch Co., 46 Colo. 102, 103 P. 280 (1909); Gulf Oil Corp. v. Alexander, 291 S.W. 2d 742 (Tex. Civ. App., 1956).

122. See generally Annot., 38 A.L.R. 2d 1265, 1305 (1954).

123. 320 Mo. 459, 8 S.W. 2d 61 (1928).

124. Although the terms of art have changed over the years as to when a municipality may be immune from suit, the court in the Windle case clearly recognized that the operation of sewage treatment facilities is not such an immune governmental function. It is the view of this author that this case would remain binding precedent today.

125. 57 Or. 547, 112 P. 529, 36 L.R.A. (NS) 140 (1911).

126. See generally Annot., 29 A.L.R. 2d 1354, 1372 (1953).

127. 32 Vt. 724 (1860).

128. 108 Mass. 261, 11 Am Rep. 352 (1871).

129. L.R. 1 Ex. 265 (1866), affirmed L.R. 3 H.L. 330 (1868).

130. Walker & Stewart, Deep-Well Disposal of Wastes, 94 J. Sanitary Eng'r. Div. of ASCE 948 (1968).

131. Cleary & Warner, supra note 25, at 492.

132. Eg., Alabama, Alaska, Colorado, Connecticut, Delaware, Florida, Idaho, Illinois, Indiana, Kansas, Louisiana, Maryland, New Jersey, New York, Nevada, South Carolina, and Wyoming.

133. Eg., Arkansas, Delaware, Kentucky, Missouri, Nebraska, Ohio, and Utah.

134. Eg., Florida, Maryland, Michigan, Oklahoma, Texas, and West Virginia.

135. Eg., Alabama, California, Colorado, Mississippi, Montana, and New Mexico.

136. Eg., California and Georgia, Indiana, Louisiana, North Carolina, Pennsylvania, and Texas, respectively.

137. See generally Final Report: Recommended Changes in Water Quality Control (Study Project on Water Quality Control prepared for the California Legislative)(1969) [hereinafter cited as Final Report].

138. Cal. Stat. §§ 13000 et. seq. (1970).

139. See generally Part One § C, supra.

140. See generally Part One § D, supra.

141. Cal. Stat. §§ 60220-23 (1969).

142. Eg., Ohio, Texas, and West Virginia.

143. Cleary & Warner, supra note 25, at 492.

144. Similar blanket provisions can be found in the statutes of Florida, Indiana, Kansas, Michigan, North Dakota, Oklahoma, Pennsylvania, and Utah.

145. Ky. Stat. § 220.610 (1969).

146. Eg., California, Georgia, Louisiana, Nebraska, New York, and North Carolina.

147. North Carolina Stream Sanitation Law, Art. 21, §§ 143 et. seq. (1969).

148. Eg., South Carolina, Arizona, and Wisconsin.

149. See generally Los Angeles v. Glendale, 23 Cal. 2d 68, 142 P. 2d 289 (1943).

150. Cal. Stat. §§ 60220-23 (1969).

151. Florida Water Resources Act of 1972, ch 72-299 (1972).

152. Eg., Ohio, Texas, and West Virginia.

153. Cleary & Warner, supra note 25, at 492.

154. Cleary & Warner, Perspective on the Regulation of Underground Injection of Wastewaters (Ohio River Valley Water Sanitation Comm., 1969).

155. Ohio Stat. §§ 1509.22; 6111.04 (1969).

156. Cleary & Warner, supra note 25, at 493.

157. West Virginia Water Pollution Control Act § 20-5A-1 (1969).

158. New York Public Health Law §§ 1220 et. seq. (1971).

159. Cleary & Warner, supra note 25, at 494.

160. See generally Part Three § A1(a), supra, for a more detailed discussion of this difficulty.

161. Cleary & Warner, supra note 25, at 492.

162. Krieger, The Law of the Underground, Civil Engineering (Mar. 1964) [hereinafter cited as Krieger].

163. Maloney & Ausness, Water Quality Control: A Modern Approach to State Regulation, 35 Albany L. Rev. 28, 58 (1970) [hereinafter cited as Maloney & Ausness].

164. See generally the enforcement and financing provisions of the Porter-Cologne Water Quality Control Act, Cal. Stat. §§ 13300 et. seq. (1970); Tenn. Code Ann. §§ 70-324 to -342 (Supp. 1971).

165. Krieger, supra note 162, at 53.

166. The agencies, approaches, and policies of various states were discussed in earlier portions of Part Three.

167. 33 U.S.C. §§ 466 et. seq. (1964).

168. 33 U.S.C. § 466 - 3a (1964).

169. 22 U.S.C. § 466 - 5a (1964).

170. 33 U.S.C. § 466 - 5d(A) (1964).

171. Id.

172. Eg., The Environmental Protection Agency is providing the largest research and development grant in its history, more than $32 million over a 7-year period, including $40 thousand per year for farm management for the Muskegon Project discussed in Part One.

173. Senate bill, S 2770 (1971).

174. Model Water Use Act, Legislative Research Center at the University of Michigan Law School, Ann Arbor, Michigan (1958).

175. Division of Water Supply & Pollution Control, U.S. Dep't. Of Health, Education & Welfare, Suggested State Water Pollution Control Act, Revised § 2(a)(1965).

176. Final Report, supra note 137.

177. Cal. Stat. §§ 13300 et. seq. (1970).

178. Maloney & Ausness, supra note 163. The research project was also instrumental in the drafting of the Tennessee Water Quality Control Act of 1971, particularly regarding its enforcement provisions. See generally Maloney, The Tennessee Water Quality Control Act of 1971, 25 Vanderbilt L. Review 331 (1972).

179. Florida Water Resources Act of 1972, ch 72-299 (1972).

180. McGauhey, Clean Water - An Environmental Challenge, 98 J. Sanitary Eng'r. Div. of ASCE 375 (1972).

181. Cal. Stat. § 13000 (1970).

182. Tenn. Code Ann. § 70-326 (Supp. 1971).

183. Design parameters were taken in part from those discussed in Recommended Sewage Standards, supra note 10, at addendum No. 2 p. 1.

184. Cal. Stat. §§ 60220; 60221 (1969).

185. Design parameters were taken in part from those discussed in Recommended Sewage Standards, supra note 10, at addendum No. 2 p. 1, and Cleary & Warner, supra note 25, at 497.